APRIL 1955

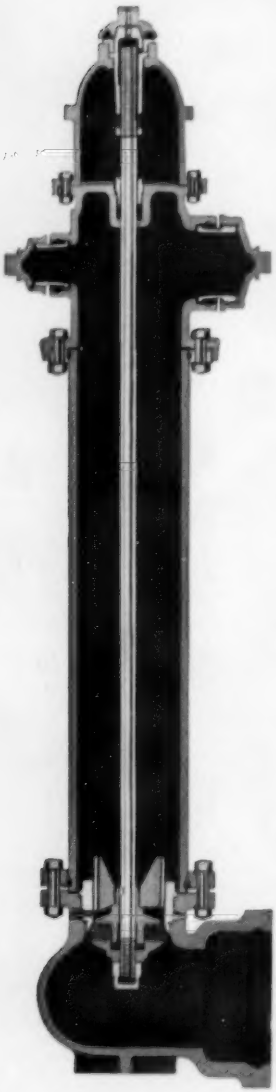
Journal

VOL. 47 • NO. 4

AMERICAN WATER WORKS ASSOCIATION

In this issue

Increasing Plant Capacity	Rankin
Rates and Administration	Hazen, Ahrens, Beadle, LaDue
System Infestations	Kelly
Determination of Radioactivity	Hahn, Straub
Ground Water on Long Island	Upson, Johnsen
Corrosion and Scale	Crockett, Popalisky
New Jersey Licensing Law	Carhart, Shaw
California Water Supply	Griffith, Holsinger, Chase
Legal Liabilities	Hathaway
Split-Treatment Softening	Cherry
Service Requirements	Mamrelli
Consumer Complaints	Bettis, King, Fuller, Wallis, Martin
FCDA Program	Nesheim
Ground Subsidence	Shoemaker, Thorley



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April 1955

Vol. 47 • No. 4

Contents

Increasing the Capacity of Existing Treatment Plant Facilities...R. S. RANKIN 303
Development of Adequate Water Rate Structures in North Carolina
RICHARD HAZEN 310
City Planning and Water Works.....GEORGE C. AHRENS 319
Management Attitude Toward Safety Engineering.....KENNETH N. BEADLE 323
Considerations in Water Works Safety.....WENDELL R. LADUE 325
Infestation of the Norwich, England, Water System.....S. N. KELLY 330
Determination of Radioactive Strontium and Barium in Water
RICHARD B. HAHN & CONRAD P. STRAUB 335
Ground Water Sources on Long Island.....JOSEPH E. UPSON 341
Conservation of Ground Water on Long Island.....ARTHUR H. JOHNSON 348
Elements of Corrosion Control.....C. L. CROCKETT 355
Sheboygan, Wis., Dental Survey Results 358
Chemical and Physical Reactions in Water Heaters.....J. ROBERT POPALISKY 359
New Jersey Licensing and Tenure Laws
KENNETH J. CARHART & ROBERT S. SHAW 364
Development of the California Water Plan.....C. A. GRIFFITH 367
Some Legal Aspects of Ground Water and the California Water Plan
HENRY HOLSINGER 374
California Ground Water Replenishment Bill.....R. W. CHASE 383
Legal Liability of Municipalities and Officials.....H. WINSTON HATHAWAY 389
Split-Treatment Method of Water Softening.....ARNOLD K. CHERRY 393
Consumer Service Requirements.....EMIL S. MAMRELLI 398
Consumer Complaints in the Southeast
JOHN R. BETTIS, THOMAS KING, O. M. FULLER & L. E. WALLIS 405
Handling Consumer Complaints.....LAWRENCE E. MARTIN 407
Reprints Available..... 408
FCDA Engineering Contributions Program.....ARNOLD NESHEIM 409
Problems of Ground Subsidence.....R. R. SHOEMAKER & T. J. THORLEY 412

Departments

Officers and Directors..... *2 P&R*
Coming Meetings ..... *8, 10 P&R*
Percolation and Runoff..... *35, 86 P&R*
Condensation ..... *62 P&R*
Correspondence..... *82 P&R*
Service Lines..... *94 P&R*
New Members..... *98 P&R*
Index of Advertisers' Products.. *102 P&R*

HARRY E. JORDAN, *Secretary* ERIC F. JOHNSON, *Asst. Secy.—Publications*
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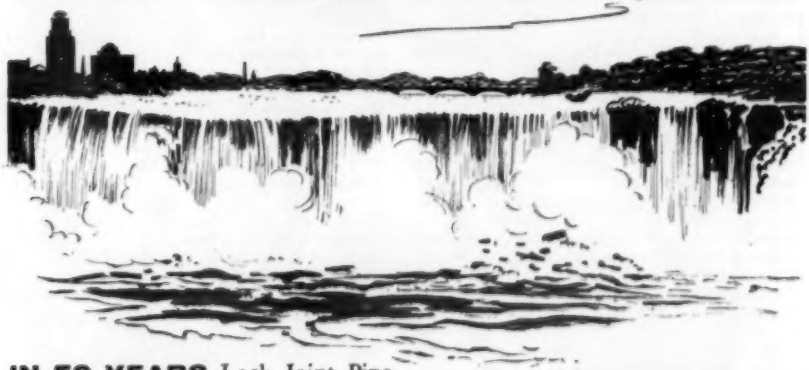

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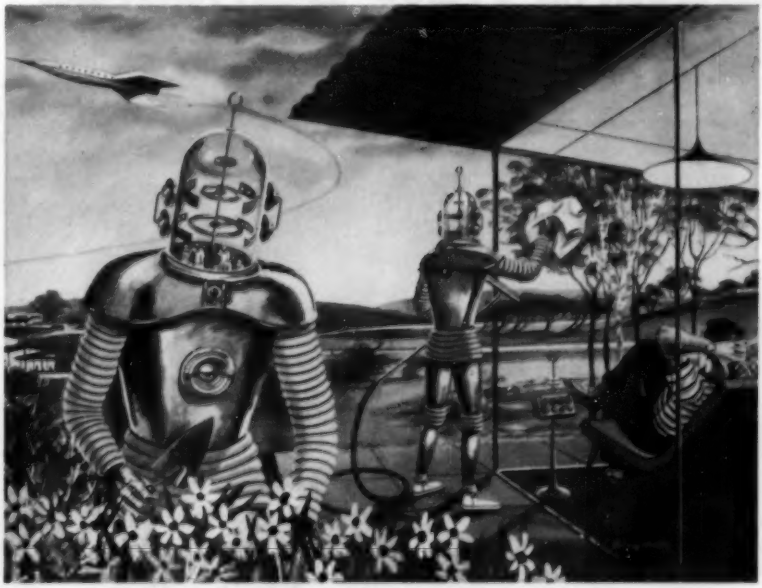
LIST OF ADVERTISERS

	P&R PAGE
AG Chemical Co., Inc.	—
Alabama Pipe Co.	—
Allis-Chalmers	—
American Agricultural Chemical Co.	90
American Brass Co., The	28
American Cast Iron Pipe Co.	—
American Concrete Pressure Pipe Assn.	12
American Cyanamid Co., Heavy Chemicals Dept.	48
American Locomotive Co.	39
American Pipe & Construction Co.	23
American Well Works	—
Anthracite Equipment Corp.	74
Armco Drainage & Metal Products, Inc.	101
Badger Meter Mfg. Co.	20, 21
Barrett Div., The	54
Bethlehem Steel Co.	85
B-I-F Industries, Inc.	22, 25, 38, 77, 86, 93
Blockson Chemical Co.	—
Buffalo Meter Co.	13
Builders-Providence, Inc.	25, 38, 86, 93
Calgon, Inc.	18
Carborundum Co., The	63
Carson, H. Y., Co.	70
Carus Chemical Co.	40
Cast Iron Pipe Research Assn., The	16, 17
Centriline Corp.	—
Chain Belt Co.	105
Chapman Valve Mfg. Co.	103
Chemical Fire & Rust Proofing Corp.	—
Chicago Bridge & Iron Co.	—
Clow, James B., & Sons	83
Cochrane Corp.	—
Cole, R. D., Mfg. Co.	42
Consolidated Western Steel Corp.	—
Crane Co.	—
Darley, W. S., & Co.	40
Darling Valve & Mfg. Co.	—
De Laval Steam Turbine Co.	24
DeZurik Shower Co.	—
Dorr-Oliver Inc.	Cover 3
Dresser Mfg. Div.	73
Eddy Valve Co.	83
Electro Rust-Proofing Corp.	—
Fischer & Porter Co.	9
Flexible Sales Corp.	—
Ford Meter Box Co., The	27
Foster Engineering Co.	—
Foxboro Co.	—
General Chemical Div., Allied Chemical & Dye Corp.	14
General Filter Co.	43
Golden-Anderson Valve Specialty Co.	—
Graver Water Conditioning Co.	81
Greenberg's, M., Sons	—
Hammond Iron Works	15
Harco Corp.	—
Hays Mfg. Co.	31
Hersey Mfg. Co.	99
Hungerford & Terry, Inc.	92
Hydraulic Development Corp.	91
Industrial Chemical Sales Div., West Virginia Pulp & Paper Co.	33
Inertol Co., Inc.	—
Infilco Inc.	49
Iowa Valve Co.	83
Johns-Manville Corp.	6, 7
Johnson, Edward E., Inc.	—
Keasbey & Mattison Co.	41
Kennedy Valve Mfg. Co., The	95
Kitson Valve Div.	67
Klett Mfg. Co.	76
Koppers Co., Inc.	97
Layne & Bowler, Inc.	19
Leadite Co., The	Cover 4
Leopold, F. B.	96
Limitorque Corp.	64
Lock Joint Pipe Co.	3
Ludlow Valve Mfg. Co.	45
M & H Valve & Fittings Co.	87
Millipore Filter Corp.	37
Morton Salt Co.	65
Mueller Co.	61
National Cast Iron Pipe	83
National Water Main Cleaning Co.	69
Neptune Meter Co.	34
Northern Gravel Co.	94
Omega Machine Co. (Div., B-I-F Industries)	77
Pekrul Gate Div. (Morse Bros. Machinery Co.)	—
Permutit Co.	78, 79
Phelps Dodge Refining Corp.	—
Philadelphia Gear Works, Inc.	64
Philadelphia Quartz Co.	44
Pittsburgh-Des Moines Steel Co.	47
Pittsburgh Equitable Meter Div. (Rockwell Mfg. Co.)	108
Pollard, Jos. G., Co., Inc.	26
Portland Cement Assn.	—
Pratt, Henry, Co.	51
Proportioneers, Inc.	22
Reed Mfg. Co., The	—
Reilly Tar & Chemical Corp.	—
Rensselaer Valve Co.	71
Roberts Filter Mfg. Co.	—
Rockwell Mfg. Co.	108
Ross Valve Mfg. Co.	—
Schleicher, Carl, & Schuell	—
Simplex Valve & Meter Co.	29
Skinner, M. B., Co.	74
Smith, A. P., Mfg. Co., The	11
Spinks, H. C., Clay Co.	84
Stuart Corp.	70
Tennessee Corp.	53
Trinity Valley Iron & Steel Co.	107
U.S. Pipe & Foundry Co.	5
Walker Process Equipment, Inc.	—
Wallace & Tiernan Inc.	32
Well Machinery & Supply Co.	89
Welsbach Corp.	67
Western Materials Co.	68
Wheeler, C. H., Mfg. Co.	30
Wood, R. D., Co.	Cover 2
Woodward Iron Co.	—
Worthington-Gamon Meter Div.	75

Directory of Professional Services—pp. *55-60 P&R*



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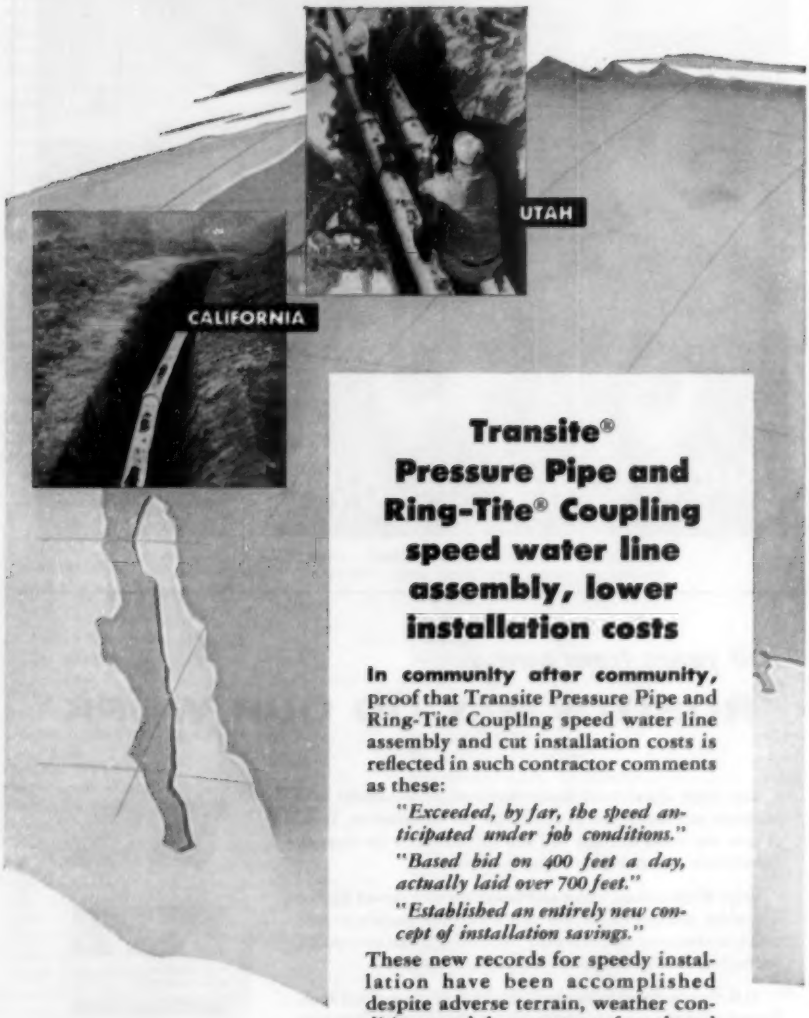

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AWWA SECTIONS

Apr. 13–15—Nebraska Section at Cornhusker Hotel, Lincoln. Secretary, E. Bruce Meier, Asst. Prof. of Civ. Eng., Univ. of Nebraska, Lincoln.

Apr. 13–15—Kansas Section at Baker Hotel, Hutchison. Secretary, Harry W. Badley, Repr., Neptune Meter Co., 119 W. Cloud St., Salina.

Apr. 14–16—Arizona Section at San Marcos Hotel, Chandler. Secretary, Quentin M. Mees, Arizona Sewage & Water Works Assn., 721 N. Olsen Ave., Tucson.

Apr. 18–20—Canadian Section at Chateau Frontenac, Quebec. Secretary, A. E. Berry, Director, Ontario Dept. of Health, Parliament Bldgs., Toronto 8, Ont.

Apr. 20–22—New York Section at Hotel Statler, Buffalo. Secretary, Kimball Blanchard, Rensselaer Valve Co., 56 Grand St., White Plains.

Apr. 29–30—Montana Section at Finlen Hotel, Butte. Secretary, A. W. Clarkson, Acting Chief, Water Section, Div. of Environmental Sanitation, State Board of Health, Helena.

(*Continued on page 8*)

AWWA ANNUAL CONFERENCE

Conrad Hilton Hotel, Chicago June 12-17, 1955

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Coming Meetings

(Continued from page 8)

May 3–5—Pennsylvania Section at Webster Hall, Pittsburgh. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg.

May 19–21—Pacific Northwest Section at Hotel Chinook, Yakima, Wash. Secretary, Fred D. Jones, Dist. Supervisor, Rm. 305 City Hall, Spokane, Washington.

Sep. 7–9—New York Section at Saranac Inn, Saranac. Secretary, Kimball Blanchard, Rensselaer Valve Co., 56 Grand Street, White Plains.

Sep. 12–14—Kentucky-Tennessee Section at Phoenix Hotel, Lexington, Ky. Secretary, J. Wiley Finney Jr., Howard K. Bell, 553 S. Limestone St., Lexington.

Sep. 14–16—Michigan Section at Durant Hotel, Flint. Secretary, T. L. Vander Velde, Chief, Section of Water Supply, State Dept. of Health, Lansing 4.

Sep. 19–21—Rocky Mountain Section at Connor Hotel, Laramie, Wyo. Secretary, J. W. Davis, Dist. Mgr., Transite Pipe Div., Johns-Manville Sales, Inc., Denver, Colo.

Sep. 21–23—Ohio Section at Neil House, Columbus. Secretary, M. E. Druley, Dist. Mgr., Dayton Power & Light Co., Wilmington.

Sep. 21–23—Wisconsin Section at Hotel Schroeder, Milwaukee. Secretary, Leon A. Smith, Supt., Water & Sewerage, City Hall, Madison 3.

Sep. 25–27—Missouri Section at the Connor Hotel, Joplin, Mo. Secretary, W. A. Kramer, Room 3, 6th Floor State Office Bldg., Jefferson City, Mo.

OTHER ORGANIZATIONS

May 1–5—Municipal Finance Officers Assn., Jung Hotel, New Orleans, La.

May 6—Annual Conference for Engineers, Ohio State Univ., Columbus, Ohio.

May 12–13—Symposium on "Automation—Engineering for Tomorrow" at Michigan State Coll., East Lansing, Mich.

May 15–19—European Assn. for Research on Fluoridation and Caries Control, Univ. of Geneva College of Dentistry, Geneva, Switzerland.

Jun. 6–10—North Carolina Water Works Operators Assn. Short Course, Univ. of North Carolina School of Public Health, Chapel Hill, N.C.

Jun. 13–Jul. 1—Short Course on "Ecology of Fresh Waters" at Linesville, Pa., sponsored by Univ. of Pittsburgh, Pittsburgh, Pa.

Jul. 11–16—Nuclear Engineering Congress, Engineers Joint Council, New York.

Jul. 18–23—International Water Supply Assn. Congress, London.

Sep. 18–22—New England Water Works Assn., Lake Placid Club, Lake Placid, N.Y.

Oct. 10–13—Federation of Sewage & Industrial Wastes Assns., Ambassador Hotel, Atlantic City, N.J.

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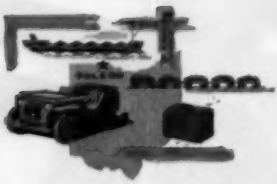

Toledo engineers prefer concrete pressure pipe for the city's water supply mains. In 1948 an 8,600-foot installation, known as the Bancroft Street Crosstown Main, was completed. Since then 24", 36", 48" and 72" concrete pressure pipe has been used in major additions to the city's water supply system. Just recently contracts have been signed by Lucas County authorities and work is in progress on additional projects in the Toledo area, involving 16" and 24" pipe.

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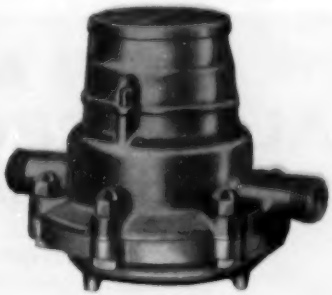

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PRODUCTION FACILITIES ALL OVER THE MAP – Wherever you are, you are near a General Chemical plant producing dry or liquid alum for water processing . . . 20 different primary sources in every section of the country. In emergencies . . . at all times . . . public works officials have found they can count on General Chemical for adequate supplies and prompt deliveries of this *preferred* water-processing alum.

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ALLIED CHEMICAL & DYE CORPORATION

40 Rector Street, New York 6, N. Y.

Offices: Albany • Atlanta • Baltimore • Birmingham • Boston • Bridgeport • Buffalo • Charlotte Chicago • Cleveland • Denver • Detroit • Greenville (Miss.) • Houston • Jacksonville • Kalamazoo Los Angeles • Minneapolis • New York • Philadelphia • Pittsburgh • Providence • San Francisco Seattle • St. Louis • Yakima (Wash.) • In Wisconsin: General Chemical Company, Inc., Milwaukee

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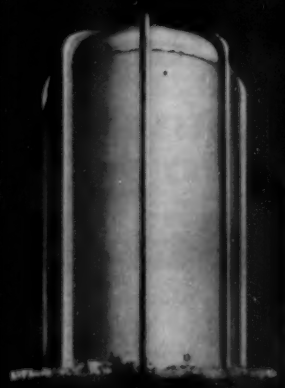
GC Allied Chemical

Serving Agriculture from Coast to Coast



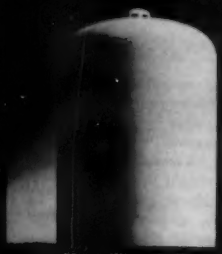
2 million Gallons

5 million Gallons

500,000 Gallons

400,000 Gallons

HAMMOND
WATER STORAGE TANKS



1½ million Gallons

For more than half a century Hammond has been incorporating integrity of design and sound construction characteristics in all its products—Steel Standpipes • Steel Reservoirs • Elevated Water Tanks • Water Spheres • Filtration and Purication Units for general water supply and fire protection systems.

Hammond Water Storing and Processing Vessels are built to all standard codes and specifications including those of the American Water Works Association, Associated Factory Mutual Fire Insurance Companies, the National Board of Fire Underwriters, the Factory Insurance Association.

100,000 Gallons

Catalog H_2O details and describes all HAMMOND Water Storage and Processing Vessels . . . Write for your copy.

HAMMOND IRON WORKS

WARREN and BRISTOL, PA. • PROVO, UTAH • CASPER, WYO. • BIRMINGHAM, ALA.

Sales Offices: NEW YORK 20 • AKRON • BOSTON 10 • BUFFALO 2 • CHICAGO 3 • CINCINNATI 2 • CLEVELAND 15 • EL PASO • HOUSTON 2 • LOS ANGELES 14 • PITTSBURGH 19 RICHMOND 20 • SAN FRANCISCO • WASHINGTON 6, D. C. • HAVANA • TIPSA BUENOS AIRES

what have

The Asiatic elephant is found in shady, wooded districts of Southeastern Asia. Huge animals that weigh up to 8,000 pounds and have a life span of about 60 years, they are easily domesticated. Many of them are used to perform useful labors of lifting and pulling. Ordinarily gentle, they can become highly dangerous when enraged or frightened.

In good condition after 100 years of service, this cast iron distribution main is one of several still functioning in New York City.

MODERNIZED **cast iron**

they in common...

THE ELEPHANT AND CAST IRON PIPE...STRENGTH!

Great strength has made the elephant one of Man's most useful animals. And Cast Iron's strength . . . shock strength, beam strength, compressive strength, make it the world's most dependable pipe . . . servant of centuries.

AND HERE'S PROOF! Listed below are some of the many water utilities still using cast iron pipe that was installed a century or more ago.

DEPARTMENT OF WATER AND WATER SUPPLY, City of Albany, New York
ALEXANDRIA WATER COMPANY, Alexandria, Virginia
BUREAU OF WATER, DEPT. OF PUBLIC WORKS, Baltimore, Maryland
PUBLIC WORKS DEPT., WATER DIVISION, Boston, Massachusetts
DEPARTMENT OF PUBLIC WORKS, DIVISION OF WATER, Buffalo, N. Y.
WATER WORKS DEPARTMENT, Chicago
COLUMBIA WATER COMPANY, Columbia, Pennsylvania
BOARD OF WATER COMMISSIONERS, Detroit, Michigan
CITY OF FREDERICK WATER DEPT., Frederick, Maryland
PUBLIC SERVICE COMMISSION, City of Hoboken, N. J., Public Water Supply
WATER BUREAU OF THE METROPOLITAN DISTRICT, Hartford, Connecticut
MUNICIPAL WATER WORKS, Huntsville, Alabama
BUREAU OF WATER, Lancaster, Pennsylvania
CITY OF LYNCHBURG WATER DEPARTMENT, Lynchburg, Virginia
MOBILE WATER WORKS COMPANY, Mobile, Alabama
QUEBEC HYDRO-ELECTRIC COMMISSION, Montreal, Quebec
PUBLIC WORKS DEPT., WATER-WORKS & SEWERAGE DIV., Montreal, Quebec
WATERWORKS DEPARTMENT, City of Nashville, Tennessee
DEPT. OF WATER, GAS & ELECTRICITY, New York, New York
DEPT. OF PUBLIC WORKS, BUREAU OF WATER, Philadelphia, Pennsylvania
BUREAU OF WATER, DEPT. OF PUBLIC WORKS, Pittsburgh, Pennsylvania
POTTSVILLE WATER COMPANY, Pottsville, Pennsylvania
BUREAU OF WATER, Reading, Pennsylvania
DEPT. OF PUBLIC UTILITIES (WATER), Richmond, Virginia
DIVISION OF WATER & SEWERS, Sacramento, California
WATER & SEWERAGE DEPARTMENT, City of Saint John, N.B.
DEPT. OF PUBLIC UTILITIES, WATER DIVISION, St. Louis, Missouri
WATER DIVISION, DEPT. OF ENGINEERING, Syracuse, New York
DEPT. OF PUBLIC WORKS, Troy, New York
CITY OF UTICA, BOARD OF WATER SUPPLY, Utica, New York
CITY OF WHEELING WATER DEPT., Wheeling, West Virginia
WILMINGTON WATER DEPT., Wilmington, Delaware
WATER DEPARTMENT, City of Winchester, Virginia
WATER DEPARTMENT, City of Winston-Salem, North Carolina
YORK WATER COMPANY, York, Pennsylvania
WATER DEPARTMENT, City of Zanesville, Ohio

TODAY... modernized cast iron pipe, centrifugally cast, is even tougher, stronger, more uniform. *Where needed and specified,* it is centrifugally lined with cement mortar to assure sustained carrying capacity throughout its long years of service.

CAST IRON PIPE'S PROVED RECORD OF DEPENDABILITY IS UNIQUE IN ITS FIELD.

Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director, 122 So. Michigan Avenue, Chicago 3.

CAST IRON

The Q-Check stenciled on pipe is the Registered Service Mark of the Cast Iron Pipe Research Association.

pipe FOR MODERN WATER WORKS OPERATION

for cleaning and developing water wells

WELTONE

the complete well cleaning preparation

WELTONE is a complete well cleaning product that combines the exclusive dispersing action of Calgon* with several other chemicals into a highly soluble, effective powder.

WELTONE IS SAFE . . . will not harm metals or concrete during the contact period, allowing cleaning with the pump in place. Weltone forms no dangerous fumes.

WELTONE IS EFFICIENT . . . at cleaning old wells or developing new wells. The high dispersive activity of Weltone effectively removes drilling muds, and the quartz, mica, silt and other materials which frequently prevent new wells from developing their full capacity.

WELTONE STERILIZES . . . and disinfects, destroying the growths of iron fixing or other bacteria which frequently contribute to lowered well capacities.

WELTONE IS EASY TO USE . . . specially processed to dissolve readily, Weltone may be added directly to the well in dry form. Use inexpensive Weltone to keep water wells at high capacity.

Write today for full information on Weltone. The descriptive folder is free, and contains complete information on the remarkable well cleaning properties of Weltone.

CALGON, Inc.

Hagan Building • Pittsburgh 30, Pa.

*Calgon is the registered trademark of Calgon, Inc., for its sodium phosphate glass (sodium hexametaphosphate) products.

ask the man from Layne

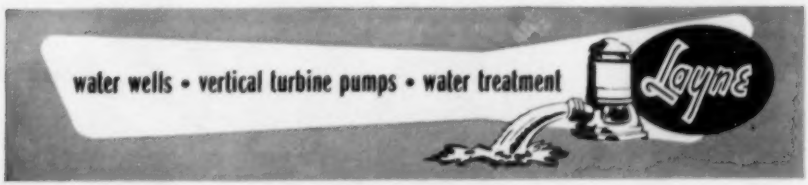
He carries knowledge from many countries under the hat he wears!

A problem on ground water development solved in Paris, France, may be the answer to a similar problem in Paris, Tennessee. World wide, factual knowledge gained the world over is available to municipalities, small and large, without cost or obligation upon request.

It's sound business judgment on any question that relates to water to "ask the man from Layne."

LAYNE & BOWLER, INC.
Memphis 8, Tennessee

Layne Associate Companies Throughout the World

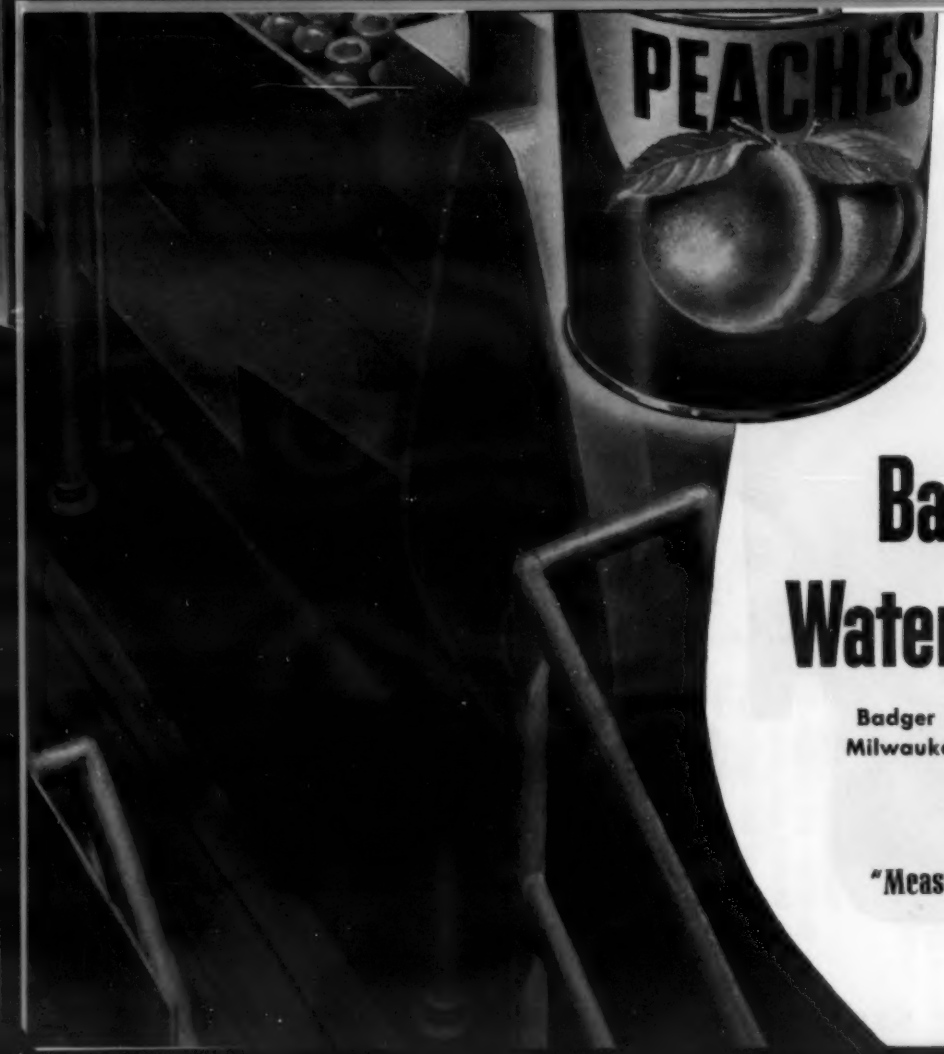


Badger meters conserve it better!

MORE than 37-billion cans of food were used by American families last year . . . yet it took *more water than produce* to make these canned products available. For example, more than 15 pounds of water were required for every pound of canned vegetables sold.

Little wonder, then, that Badger meters

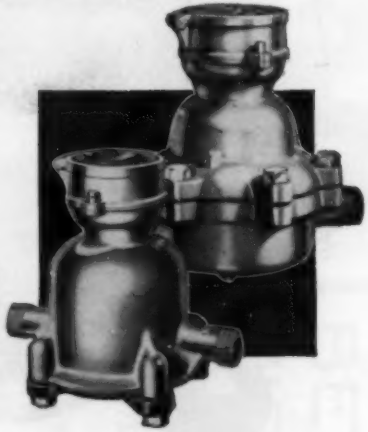
tables sold.



Little wonder, then, that Badger meters serve so importantly in thousands of communities. They make certain that homes and industries receive a fair share of the water supply . . . pay only for the water they use.

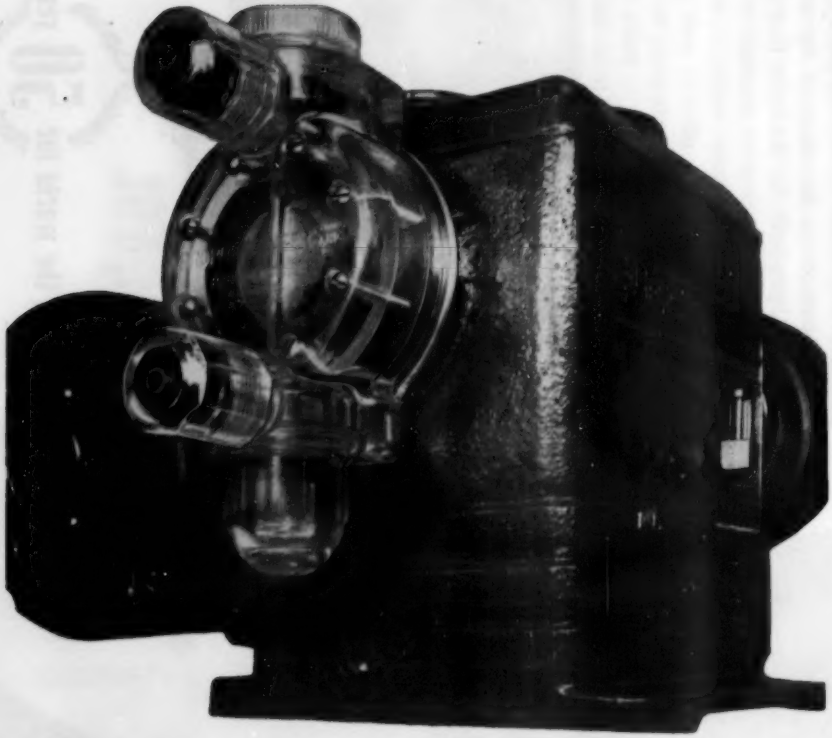
Famous Badger meters measure water precisely . . . help eliminate waste . . . make water departments more efficient and self-supporting. And service records prove the dependability of Badger meters . . . prove that there are no finer water meters to be had — anywhere!

Badger Water Meters



Badger Meter Mfg. Co.
Milwaukee 45, Wisconsin

"Measuring the water of the world for 50 years"



THREE GOOD REASONS FOR SELECTING

Chem-O-Feeder

1. *All-purpose pump* — corrosion-proof measuring chamber safely handles almost all water treating chemicals — at rates from 0.2 to 57 gals. per hour.
2. *Complete kit* — furnished with all necessary items for quick easy installation — easily adapted to all types of constant rate or flow proportional feeding systems.
3. *Maintenance-proof design* — complete feed control mechanism operates in "oil bath" lubrication.

See how Proportioneers Chem-O-Feeder can solve your water treating problems — write for Bulletin 1225. Proportioneers, Inc., 365 Harris Ave., Providence 1, R. I.

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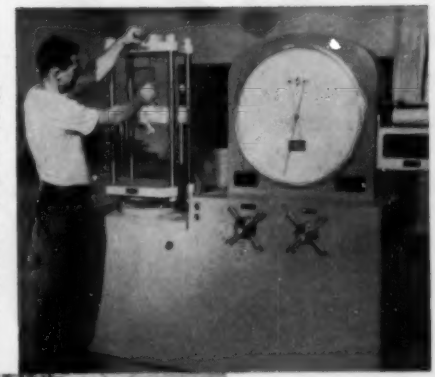
DIVISION OF B-I-F INDUSTRIES, INC.

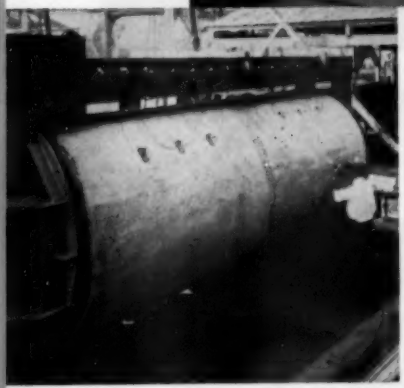
BUILDERS IRON FOUNDRY • OMEGA MACHINE CO. • BUILDERS-PROVIDENCE, INC.

BIF METERS FEEDERS CONTROLS

Standard 6"x12" test cylinders are made from the same batch of concrete as the pipe, cured with the pipe in the same steam box and are subjected to compression tests.

Steel reinforcement rods are tested to determine their physical properties. Stress-strain diagram may be plotted on recorder at right.





Completed pipe sections receiving hydrostatic test. Water pressure is increased until ultimate failure of the pipe section; research engineer makes periodic examinations as pressure goes up.

Resistance to external loadings is determined by careful checking as pipe receives three-edge bearing test.

BETTER PIPE

at a lower cost to you

What this means to you...

Cost. Lowest possible cost to you through efficient utilization of materials.

Quality. Savings, yes, but all pipe must be constructed in accordance with sound and conservative engineering principles.

Safety. A built-in safety factor is always a part of American's engineered products.

Know-how. Product information for you from engineers who KNOW from experience and tests what each class of pipe can do.

Materials. Highest quality materials guaranteed by American's policy of testing and proving *before* using.

Future. A research program to help solve problems which may confront you in the future.

Take advantage of these plus-factors in your next project—our 45 years of experience in the development of superior pipe products is at your service. Write or phone for any additional information.

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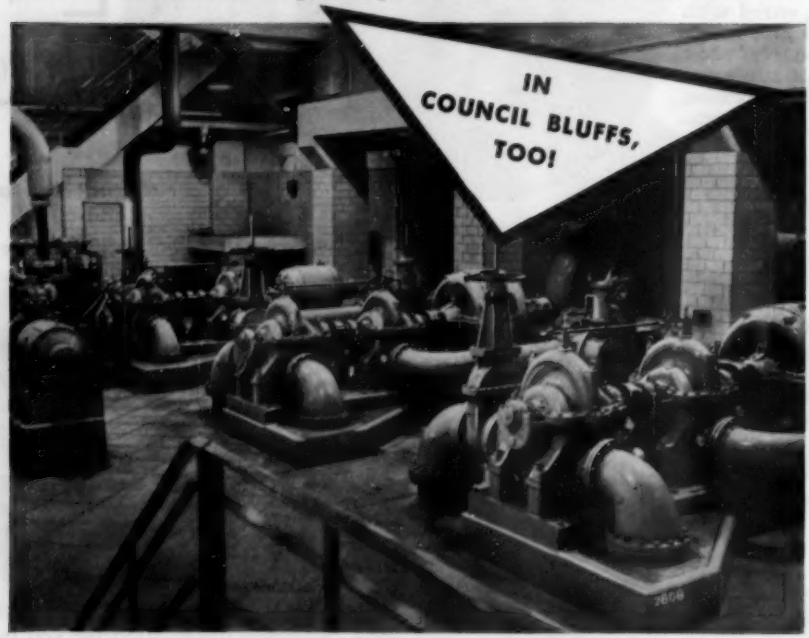
Concrete pipe for main water supply lines, storm and sanitary sewers, subaqueous pipe lines

DE LAVAL pumps America's water...



In Council Bluffs, Iowa, as in more than 80% of America's municipal stations, De Laval centrifugal pumps are faithful public servants.

On the line are two motor-driven De Laval 14/12 units. Each unit has two pumps in series designed for 4,500 gpm against a total head of 245 feet at 1,200 rpm. Another pumping unit, dual driven by a gas engine at one end and a motor at the other, consists of two De Laval 12/10 pumps in series. Operating conditions for these are 3,750 gpm against a head of 235 feet at 1,200 rpm.

Fifty-three years experience in pump building, during which time De Laval has introduced numerous "firsts" in pump design, is the reason for this nation-wide preference.

NOTE:

Have you considered the dollars and cents savings you can make by replacing your old pumps with new, more efficient De Laval units? Write to De Laval for Pump Fax bulletin which includes a valuable "power savings" chart.

DE LAVAL *Centrifugal Pumps*

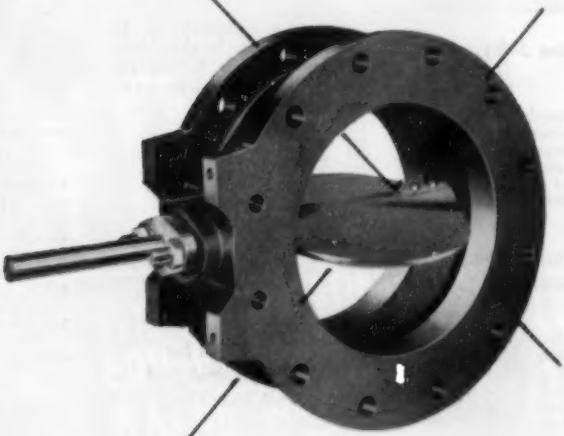
DE LAVAL STEAM TURBINE COMPANY

822 Nottingham Way, Trenton 2, New Jersey

DL 2504

Blue Chip

For water works service... specify AWWA standard butterfly valves...



... by Builders-Providence

365 Harris Ave.,
Providence 1, R. I.

BUILDERS-PROVIDENCE

DIVISION OF B-I-F INDUSTRIES, INC.

BUILDERS IRON FOUNDRY • PROPORTIONEERS, INC. • OMEGA MACHINE CO.

BIF METERS FEEDERS CONTROLS

Pipe Line Equipment
WATER • GAS • SEWER

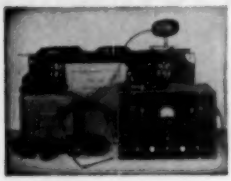
Bottled Gas Lead Melting Furnace

Asbestos Joint Runners

Best quality asbestos rope, brass caps attached to each end. Equipped with clamps.

M-D Cut-In Connections for Sewers

A light cast iron fitting with bell end for connecting house service with main sewer pipe without necessity for placing a Y-branch or T-branch in the sewer line.



Leak Detector

A truly fine instrument designed to solve even the most difficult leak detecting problem.

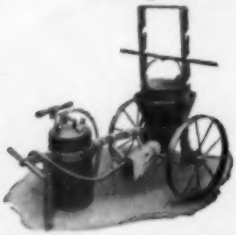
Calking Tool Outfit

For water mains up to 12". Strong leather bag. Keeps the right tool for every job within easy reach.

Test Plugs for Bell or Spigot End Cast Iron Pipe.

On this page are shown only a few of the hundreds of items to be found in the POLLARD Catalog. Write for a copy of Catalog No. 26K.

Portable Lead Melting Furnace



A handy outfit for quick action, equipped with gasoline burner.

Pipe Cutter

Inexpensive way of cutting pipe. Every wheel in contact with the pipe is a cutting disc, so cutter need be moved only a short distance to cut entirely around the pipe.

Tapax

The original manhole cushion. Takes the bang out of manhole covers.

New "Electronic Witch" M-Scope Pipe Finder

The first really NEW pipe Finder in 20 years.

JOSEPH G. POLLARD CO., INC.

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MAIN OFFICE AND FACTORY
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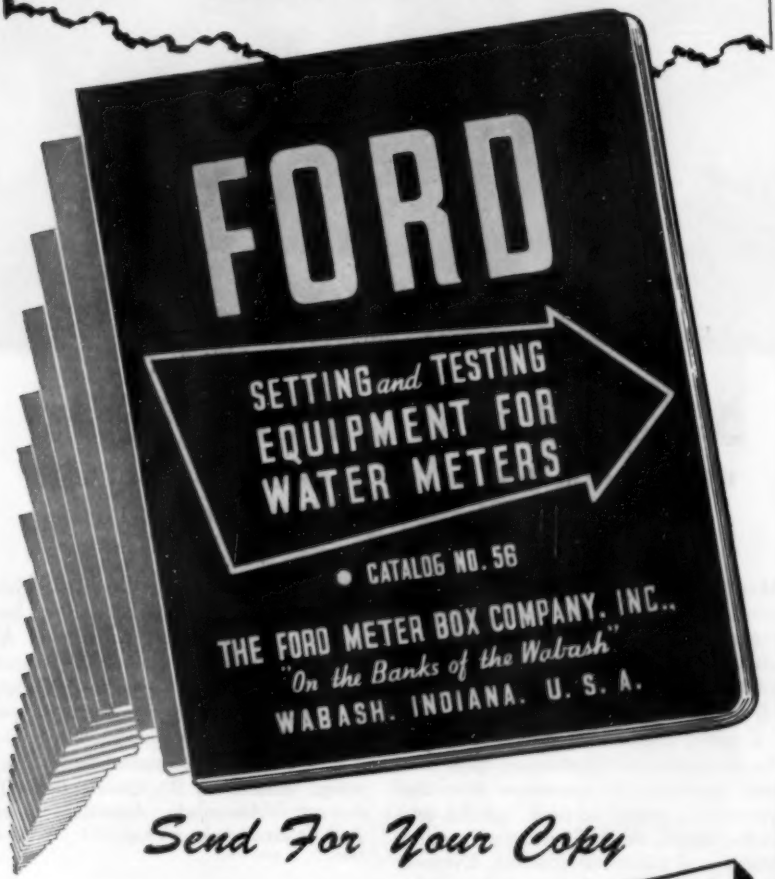
Ready Now...

Catalog No. 56


FORD
SETTING and TESTING EQUIPMENT FOR WATER METERS
• CATALOG NO. 56
THE FORD METER BOX COMPANY, INC.
"On the Banks of the Wabash"
WABASH, INDIANA, U. S. A.

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THE FORD METER BOX COMPANY, INC.
Wabash, Indiana

FOR BETTER WATER SERVICES

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MANHOLE STEPS:

GIVE THEM AN EXTRA MARGIN OF SAFETY WITH CORROSION-RESISTANT EVERDUR

Manhole steps—of all sewage treatment and waterworks structures—need *extra* corrosion resistance and dependability. Everdur* gives it to them . . . and adds the strength that really pays off . . . in greater safety.

Everdur Copper-Silicon Alloys deliver the same corrosion resistance—*plus ease and economy of operation over the years*—to gates, screens, guides and bolts, weirs, float chambers, troughs, stems and electrical conduit. Everdur is easily fabricated into lightweight, built-up wrought-metal assemblies.

Depending on type or composition, Everdur Alloys can be worked hot or cold. You can form, forge, weld and machine them. They are available in the form of plates, sheets, rods, tubes, electrical conduit and casting ingots.

Write today for Anaconda's free booklet, "Everdur Copper-Silicon Alloys for Sewage Treatment and Waterworks Equipment." For specific help in selecting the right alloy for your equipment, consult our Technical Department. *The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.* 5814GA

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EVERDUR

ANACONDA®

COPPER-SILICON ALLOYS

STRONG • WELDABLE • WORKABLE

CORROSION-RESISTANT

How to Locate Water Leaks

WITH SIMPLEX PITOT EQUIPMENT

WHY not decrease your load and stop pumping to waste? Locate the hidden leaks which waste thousands of gallons per day per mile of main . . . far more than usually guess-timated!

Locating these leaks with Simplex Pitot Equipment costs only a tiny fraction of the value of the water being wasted. You get accurate flow records with minimum effort . . . valuable data that will help you to reduce "unaccounted-for water" to a minimum.

PITOT ROD

Simple, rugged and lightweight. Easily installed on any pipe or main. Special clamp holds tube firmly in position against water pressure.

Low coefficient gives high differential pressure for greatest accuracy.

MANOMETER

Quickly connects to a Simplex Pitot Rod with flexible tubing. You then have a simple, sensitive and inexpensive instrument for indicating rate of flow.

Can be used for wide flow ranges . . . low or high.

PITOT RECORDER

Connects easily to Pitot Rod. Eight-inch chart records flow data. Simple and rugged construction . . . no delicate mechanisms . . . yet sensitive and accurate.

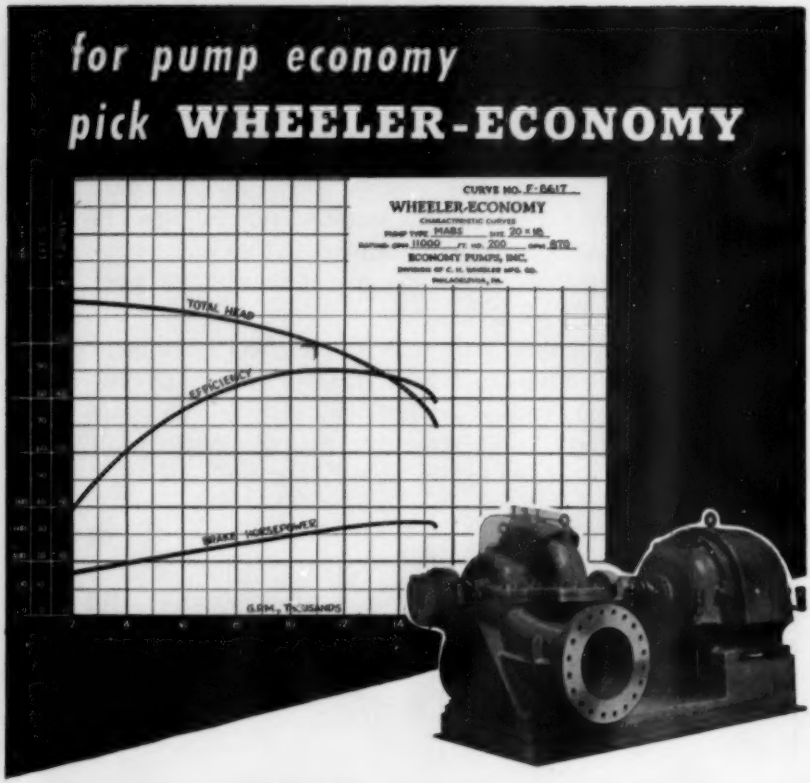
Sturdy carrying case. Leveling feet. Reliable 7-day clock movement for chart. Accurately calibrated.

Get the Facts!

Free 20-page Technical Bulletin 1300. Full instructions for use and care of Pitot equipment. Seven pages of helpful formulae, tables, curves. Write to Simplex Valve & Meter Co., Dept. JA-4, 7 E. Orange St., Lancaster, Pa.

SIMPLEX®

VALVE AND METER COMPANY



The Type M pump shown here is typical of Wheeler-Economy pumps for water works service. Its design embodies heavily ribbed cases and high pressure flange specifications where required. Single or dual volutes are available. Sleeve bearings (oil lubricated) or ball bearings (either oil or grease lubricated) may be furnished in most water works sizes. The pump shown has oil lubricated ball bearings.

Typical performance charts show that high efficiencies over a wide range of operating conditions are yours when you specify Wheeler-Economy.

Catalog WA-1052 illustrates many styles and installations for water works service. Write for your copy.

WE-401

WHEELER-ECONOMY PUMPS

ECONOMY PUMPS, INC. • DIVISION OF C. H. WHEELER MANUFACTURING CO.
19TH AND LEHIGH PHILADELPHIA 32, PA.

HAYS

AMONG THE HAYS WATER WORKS PRODUCTS that you need to save time and expense . . .

DRILLING MACHINE

TAPPING MACHINE

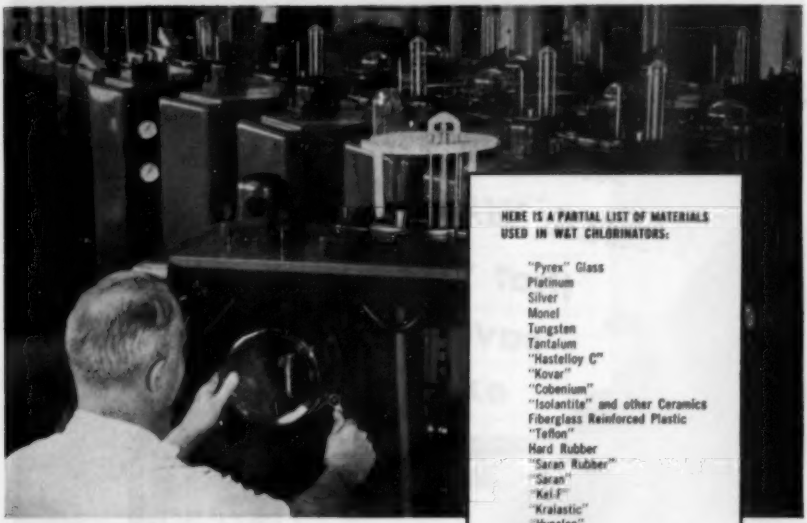
Write for literature, or ask "The Man from Hays"

(FOR OVER 80 YEARS)

CORPORATION STOPS • CURB STOPS
SERVICE BOXES • FITTINGS
BRANCH CONNECTIONS • GOOSENECKS

HAYS

WATER WORKS PRODUCTS
HAYS MANUFACTURING CO.
ERIE, PA.



HERE IS A PARTIAL LIST OF MATERIALS USED IN W&T CHLORINATORS:

"Pyrex" Glass
Platinum
Silver
Monel
Tungsten
Tantalum
"Hastelloy C"
"Kovar"
"Cobenium"
"Isolantite" and other Ceramics
Fiberglass Reinforced Plastic
"Teflon"
Hard Rubber
"Saran Rubber"
"Saran"
"Kel-F"
"Kralastic"
"Hypalon"
"Uscolite"
Unplasticized Polyvinyl Chlorides
Plasticized Vinyls
"Lucite"
"Plexiglas"

Where glass is needed, glass is used . . .

How well chlorination equipment does its job depends not only on proper design but on the selection of the right material for each part of the assembly.

In W&T equipment, every part is employed where it best suits the purpose for which it is intended. And every part gives good service because it is made of the right material for the job. Glass, metals, ceramics, and many types of plastics are used throughout Wallace & Tiernan's complete line of chlorinators — and each is selected for its ability to give you the most satisfactory operation under your plant conditions.

Since 1913, W&T research has consistently sought out new designs, principles and materials. Every new development is placed under rigid field tests to prove it can meet the exacting standards that dependable and economical chlorination demands.

When you depend on W&T equipment, you have the assurance that 40 years of experience in the chlorination field is being used to bring you the best in design, parts, and materials — selected and tested specifically to fit the need.

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"Make Your First Choice Equipment That Lasts"

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY

Journal
AMERICAN WATER WORKS ASSOCIATION
VOL. 47 • APRIL 1955 • NO. 4

Increasing the Capacity of Existing Treatment Plant Facilities

R. S. Rankin

A paper presented on Oct. 20, 1954, at the Southwest Section Meeting, El Paso, Tex., by R. S. Rankin, Director, San. Eng. Tech. Div., Dorr-Oliver Co., Stamford, Conn.

WHEN treatment plants are new, operations can be carried out smoothly and capacity is usually adequate. Unfortunately, however, after years of service, plants become obsolete, making it difficult to meet the increasing demands of a growing community. When this happens, the operator probably would like to scrap the old plant and build a new one. In some instances, this might be the wisest course to follow, but most water treatment facilities are built for permanence and represent a considerable investment. They usually include tanks and other structures that are in sound condition and may lend themselves to an economical plan of modernization. Such a project may enable a community to obtain greatly increased output of treated water at a fraction of the cost of new works. Numerous examples testify to the wisdom of exploring this idea in all its variations before scrapping the old facilities.

Richmond Plant

One of the outstanding examples of increasing the output of existing facilities at comparatively small cost is the work done in 1932 by Marsden C. Smith, at Richmond, Va. His methods have since been applied to hundreds of other water treatment works. In 1932 the Richmond plant consisted of four coagulation basins which were typical of those in many other plants built prior to that time. Raw water was mixed with chemicals for a few minutes and discharged into the basins, where chemical precipitation was supposed to clarify the water and make it suitable for filtration. Increased output was needed, but poorly clarified water continually decreased filter runs. This resulted in the use of more plant output for wash water and less for distribution.

The trouble arose during the great depression, when expenditures for new

works had to be avoided. Smith knew he had to devise some solution to the problem which did not require new construction. It was decided to explore ways of improving upon old facilities. By exhaustive laboratory tests, it was demonstrated that increasing the time of gentle agitation of chemically dosed water beyond the existing standard greatly improved the quality of the settled effluent. Extending the flocculation period to as much as 1 hr not only did no harm but actually improved the settling characteristics of the floc to such an extent that the total duration of pretreatment could be materially reduced.

The next problem was how to apply laboratory results to plant operation. It was decided to utilize the influent end of the existing basins as a gentle-mixing zone. The length of this zone was to be sufficient to give a theoretical detention of 70 min. A baffled-mixing design was unsuitable because the head requirement could not be met and the expense would have been excessive. Smith concluded that the only solution was to proceed with the development of a new design for mechanical mixing which would fulfill the requirements. The result was the first installation of the horizontal-shaft type of flocculating equipment at a cost far below any other possible type of mixing arrangement.

The effects were startling. Instead of a slow-settling floc spread out over the 700-ft length of the basin, almost all the floc settled within 50 ft of the last paddle. During the first 4 months of operation, alum consumption dropped from 76.5 ppm to 39.4 ppm, resulting in a saving of $1,400 per month. The installation paid for itself in chemical savings alone in less than 2 years. Treated-water color was reduced almost in half, and a vast improvement was noted in the length of the filter runs and the quality of the treated water. This is an excellent illustration

Fig. 1. View of Plant at Kansas City, Mo.

Flocculation and sludge removal equipment has been added to existing basins.

of what can be done to improve a plant without the addition of a single major structure.

Kansas City, Mo., Installation

Another place where existing structures were utilized and equipment was installed to give greatly increased capacity is the Kansas City, Mo., water treatment plant. As originally placed in operation in 1927, this plant, designed primarily for turbidity removal, included four mechanically cleaned presedimentation basins, followed by circular mixing basins with tangential feed, where the water was dosed with lime and alum. The water then passed through primary and secondary coagulation basins. Plant output was generally limited to 50–60 mgd, because one of the three primary basins was out of service much of the time for cleaning.

Increased consumption due to rapid city growth and war industry demands emphasized the need for more efficient pretreatment facilities and the desirability of softening the water. Raw water came from the muddy Missouri River and was quited hard, particularly in the winter.

A joint study was made in 1940–41 by two consulting firms. High-rate solids-contact process ("upflow") units were coming into general use then, and the engineers gave full consideration to their possible application. Extensive reconstruction would have been necessary, however, to adapt the plant to such facilities and the cost was considered prohibitive. The engineers, after careful study, submitted recommendations which, with no new sedimentation tanks, would more than double the potential output of the plant. The city adopted the plan and proceeded to put it into operation. A hydraulic jump for flash mixing of chemicals was provided by constructing a flume or trough across the circular mixing tanks of the original plant, thus avoiding major piping changes.

Next, the three original primary coagulation basins, each 330×300 ft, were divided into separate flocculation and sedimentation compartments by the construction in each unit of a cross wall about 60 ft from the inlet side. Numerous vertical ports were built into the cross walls to aid in distributing the flocculated water into the sedimentation compartment. Each sedimentation compartment was furnished with sludge removal equipment for the first 155 ft of flow-through length, with the remaining portion of the tank floor to be manually cleaned as required. A sludge-pumping station was built right in the basin on the centerline at the edge of the mechanically cleaned section. Figure 1 shows a view of the improvements.

The two secondary coagulation basins were designed originally to add coagulant to the primary-basin effluent. Apparently, however, coagulation in the second stage was inadequate. The insufficiency was overcome by the installation of flocculating equipment in a compartment formed by constructing a transverse baffle wall at the influent end of each of the second-stage basins. The drive chains of all the flocculating equipment were made readily accessible in dry wells, with the drive shafts passing through stuffing boxes to the paddles in the basins.

The addition of softening facilities, together with the greatly increased plant capacity, has proved very satisfactory. The output of the plant was raised from the original 50–60 mgd to 150 mgd, at a fraction of the cost that

new structures for the additional capacity would have entailed.

New Orleans Program

The New Orleans, La., expansion program at the Carrollton Purification Works is another example of utilization of existing basin capacities. By the installation of modern equipment, a great increase in treatment plant output has been made possible. New Orleans, which gets its water supply from the Mississippi River, was one of the earliest cities in the country to install a rapid sand filtration plant. Huge coagulation basins were constructed to allow adequate precipitation of the mud carried in the raw water. Treatment with lime and ferrous sulfate was originally adopted and still continues because no more economical coagulant has been found.

Improvements have been made to the original plant from time to time; the last major addition (prior to the present program) was built in 1935. In recent years demand increased to the extent that additional pretreatment facilities were indicated. It was apparent that the older method of operating the sedimentation tanks was not getting the most out of them, and the installation of modern equipment seemed desirable. Accordingly, a study was made to determine the bethod of increasing capacity at the lowest cost.

The New Orleans Sewerage and Water Board decided that existing basin capacity was ample for future needs, provided more efficient use could be made of it. Rising demands

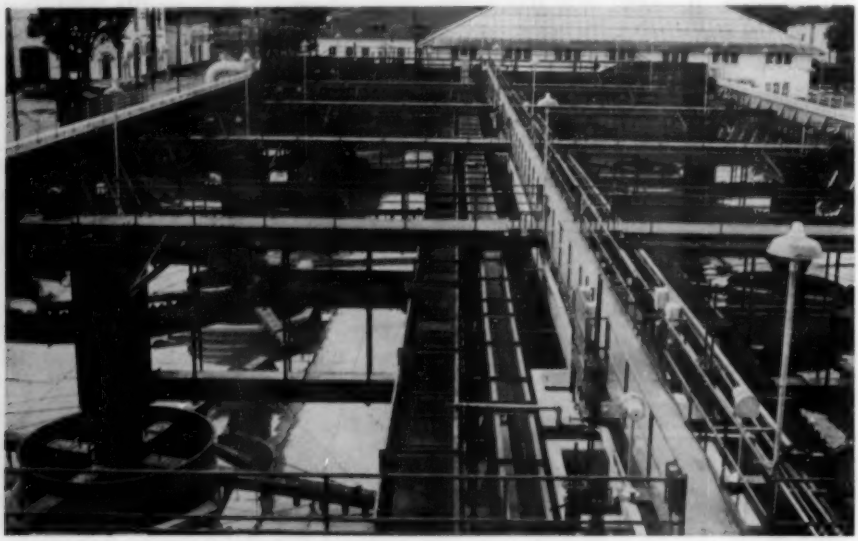

Fig. 2. Revamped Basins at New Orleans

Six treatment units were installed in these two formerly unused basins, increasing plant capacity 100 mgd.

required an immediate increase in pretreatment facilities to a capacity of 100 mgd. This initial expansion was to be followed by a further increase at a slower pace, to take care of future demands. The first or immediate increase illustrates the use of existing tanks.

Two basins formerly used for removal of grit from the raw water had been out of service for some years owing to alterations in the overall scheme of treatment. These basins, built in 1908, were approximately 75 × 340 ft, with a 16-ft water depth. They were located with the floor only 3–4 ft below ground level. The walls were constructed with counterforts or buttresses, on 10-ft centers, inside the tank. The plan proposed was to convert the two basins into upflow, blanket type units with a capacity of 50 mgd each, thus adding 100 mgd to existing pretreatment basin capacity. Disturbance of the tank floor was to be avoided as far as possible, because the floor slab was resting on the soil and was not otherwise supported or tied into the walls. The proposed solution was the installation of six units in each basin, each unit to handle 8.67 mgd. Formal competitive bids were taken, and the contract was awarded to the author's company. The finished basins are shown in Fig. 2.

The application of chemicals presented an interesting problem. As previously stated, New Orleans has for years used lime and ferrous sulfate as reagents to precipitate the turbidity and partially soften the water. It was undesirable to change the types of coagulants because all the operators were familiar with them. The problem was how to flash-mix these chemicals with the raw water. Individual feeding of chemicals and mixing ahead of each newly installed unit was considered unnecessary, and would have cost more than application at a single point.

The solution adopted was to use the available excess head in the influent feeder main and mix the chemicals with the raw water by means of a hydraulic jump constructed in the inlet flume across one end of the tank. Careful calculations were necessary to determine proper flume design so that the excess head in the 50-mgd flow could be properly utilized for flash mixing without creating undesirable waves. Fortunately, the new method has resulted in performance very close to that predicted.

Each upflow unit is fed individually through an adjustable control gate in the main influent flume, which runs along the central wall between the two tanks. The effluent is removed through circular flumes surrounding each unit and also through longitudinal flumes along both sides of each tank, with up to 50 per cent being removed through the circular flumes.

Sludge piping laid on the floor runs to sludge control manholes constructed in the area between two counterforts at a location where the rotating arms will not interfere. Thus, what was formerly an unused pair of tanks has been converted into a 100-mgd plant addition with a minimum of changes in the structures. In October 1954 the installation was going through a trial period, including adjustments and training of operators. It was expected to be ready in time to meet the heavy winter demand.

Smaller Plants

A number of smaller plants with pretreatment structures in good condition have also found it advantageous to convert them into high-rate upflow

units by the addition of suitable equipment. At far less cost than new structures would entail, plant capacities have often been doubled. Two typical examples are the plant serving North Miami Beach, Fla., and a larger installation at Ardmore, Okla.

North Miami Beach

North Miami Beach, a suburb of Miami, in 1950 acquired the plant of a private water company that previously served the area. The facilities included two concrete tanks, 30 ft in diameter and 15 ft deep, used to soften the well supply under a fill-and-draw system of operation. The village, through a consultant, prepared plans for converting the two tanks to upflow units by the addition of appropriate equipment. As bids for equipping the two units exceeded the available funds, it was decided to start with one unit. The specified capacity for a single unit was 700 gpm average and 1,400 gpm maximum. This would satisfy current demands. Construction of the unit, along with other improvements, was completed in early 1952. After a trial period it was possible, when using lime and activated silica, to soften more than 1,400 gpm continuously and to reduce the total hardness from about 270 ppm in the raw water to 50 ppm in the finished water. Turbidity in the effluent of the upflow units averaged 1–2 ppm.

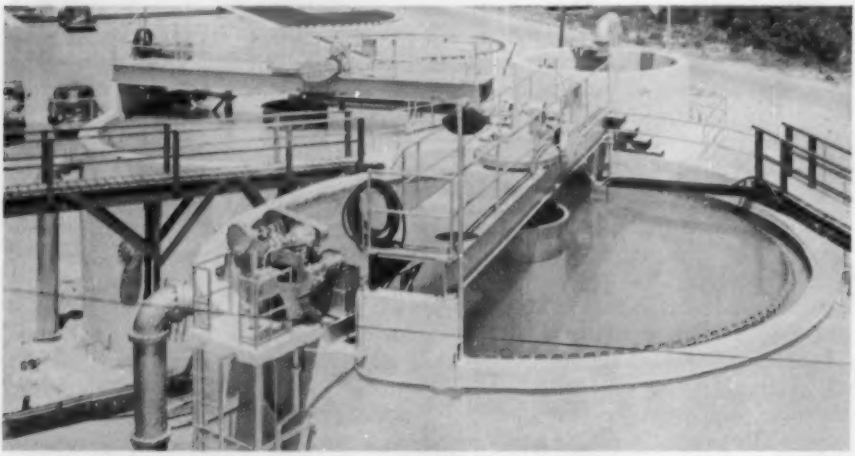

Fig. 3. Two Converted Tanks at a Small Plant

Conversion of two concrete tanks has allowed this plant at North Miami Beach, Fla., to meet growing needs. Capacity of the two upflow units is 2,800 gpm.

By the end of 1952, the demand had increased to an average of 1,250 gpm. In 1953 additional equipment was purchased and installed in the remaining tank, thus giving a capacity of 2,800 gpm, which may suffice for a few years.

The interesting feature of this installation is that no change in the tank structure was necessary. The influent was brought in over the top of each tank, a new steel effluent trough was

attached around the inside wall at the water surface, and a suitable effluent pipe was connected to this trough. The mechanism in the tank was supported on new steel beams spanning it. A special sludge well was included with the equipment to avoid disturbing the tank floor. The sludge from the low-magnesium water thickens quite rapidly and is bled off into a holding tank, from which it is pumped to a lagoon. Every one concerned seems pleased with the new facilities, which have provided a great increase in capacity without the necessity of building new tanks. A view of a finished upflow unit is shown in Fig. 3.

Ardmore

Ardmore, Okla., is engaged in the construction of additional facilities. The original water treatment plant included a typical coagulation basin, 40 ft wide and 100 ft long, with a 12-ft water depth. The engineer recommended that this basin should be converted to a high-rate upflow type. The water source is a lake requiring occasional softening and turbidity removal, using lime, alum, and silica as coagulants. As originally designed, the basin produced an average of 5.8 mgd (equivalent to 1 gpm per square foot), with a maximum of 8.0 mgd, nearly 140 per cent of average. Owing to hydraulic conditions at the influent end of the plant, the water depth in the converted unit could not exceed 12¼ ft.

Plans call for two upflow units, the water entering the basin through a new pipe and passing into a tee with branches going to each of the units. Two new circular overflow launders and new effluent launders along the long side of the tank will be required to handle the increased flow.

Owing to the shallow tank depth, it was necessary to cut into the tank floor to construct the sludge concentration wells, but no serious problem was presented. To utilize the full tank depth, the outer face of the launders was sealed against the side walls, permitting the water level to reach the top of the concrete walls.

Conclusion

The illustrations discussed are typical of the variety of methods which can be used to overcome handicaps in older plants with a minimum of expenditure. Careful studies are advisable for each problem, because no two are alike. The fact that alterations and improvements can be made in existing structures built as long as 40 years ago is a tribute to the quality of the construction work in the water plants. Superintendents and operators would do well to examine their plants carefully when increased capacity is needed. There are many ways of adapting new ideas to old installations.

Development of Adequate Water Rate Structures in North Carolina

Richard Hazen

A paper presented on Nov. 9, 1954, at the North Carolina Section Meeting, Asheville, N.C., by Richard Hazen, Partner, Hazen & Sawyer, New York.

WATER and sewer rates should yield enough revenue to finance the works on a sound basis, and should be arranged so that small and large users, inside and outside the city limits, pay their proper share of the costs. These basic requirements apply equally to municipally owned and privately owned works. There are, however, important differences between municipally and privately owned works in the legal and financial arrangements. This paper is concerned principally with municipally owned systems.

The importance of adequate revenue is so obvious that there should be no need to dwell on it. Many superintendents, however, boast of the fact that their utility rates have not been changed for 20 years or more. They do not realize that the utility has been losing ground steadily. This loss is usually reflected in three ways: [1] inability to pay adequate salaries and to maintain a staff competent to operate the system; [2] inability to finance even small replacements and repairs as they are needed; and [3] absence of any reserve to help finance major improvements.

On the other hand, some water departments have a long history of making money for the community, and each year substantial sums are taken from the department for general municipal purposes. Although this practice may assure revenue for the utility when it is needed, rates much in excess of actual needs are undesirable in that they constitute a form of indirect taxation. One objection to financing water and sewer departments entirely out of rates is that too much of the burden is placed upon the actual users of the utilities and not enough upon all property owners who benefit from the existence of the systems. Water rates that yield revenue substantially in excess of needs aggravate this situation.

Self-supporting Basis

There is much popular approval today for putting both the water supply and sewer systems on a self-supporting basis. This has been common practice in the water works field for many years, but is relatively new for sewer systems, historically financed from general tax revenues or special assessments. The self-supporting procedure runs counter to the recommendations made by a joint committee of the ASCE and the American Bar Assn. in a 1951 report on rate structures (*1*). The report stresses the fact that property owners benefit substantially from the existence of water and sewer sys-

tems, whether or not they actually use the facilities, and that they should help pay for the works. In recognition of this situation, the water and sewer rates are arranged in some communities to provide only part of the needed revenue, the balance being obtained through front-foot assessments, general taxation, or a combination of both. This procedure is followed by the Washington Suburban San. Dist., the Los Angeles water department, and many other municipalities.

The validity of the joint committee's position is recognized in a 1954 AWWA committee report (*2*). The AWWA committee, however, states that, because many cities are hard pressed to find sufficient property tax revenue for other municipal services, ". . . it would seem to be unrealistic to propose generally that any considerable amount of utility revenue be collected through property taxes as payment for intangible benefits to property as a whole, no matter how alluring the theory upon which such proposals are based." The AWWA committee concludes that ". . . most of the income will be derived from the water users and that the portion received from taxes, assessments, or other levies will usually be limited to: fire protection; assessments on benefited property for main extensions; and occasionally some tax aid, grant, or donation to help finance a major improvement." It should be noted that even where a self-supporting system is favored, it is common to require property owners and real estate developers to pay for water mains and sewer extensions.

Establishment of Rates

It is not possible to estimate future costs and revenue exactly, but efforts should be made to establish rates that will be adequate for a period of 10 years or more. Frequent changes in rates are undesirable from a public relations standpoint and make it impossible to schedule extensions and improvements. In setting up a rate schedule, consideration must be given to:

1. Capital expenditures necessary in the near future to provide adequate service.

2. Increases in labor requirements and, particularly, in wages that must be paid to replace employees upon death or retirement.

3. Indirect costs, such as pensions and city overhead, that may or may not be charged to the utilities, depending upon the policy adopted.

4. The effect of increasing rates on water consumption and sewage flows. (Where extensive water works improvements are financed by water rates, or sewerage system improvements by a surcharge on the water rates, the increase in utility costs may be 50–100 per cent. An increase of this magnitude may affect industrial and commercial water consumption substantially.)

The determination of adequate water and sewer rates is not simply a matter of accounting. A thorough understanding of the operations and engineering problems involved is essential. In determining sewer charges and special rates for treatment of industrial wastes, particular care should be taken to evaluate the real factors properly and to disregard the unimportant ones.

The mathematics of rate making are far from precise, and it is important to know how far it pays to carry the calculations. This is particularly true under municipal ownership where plant and cost records often are not

kept in the detail required by public service commissions. For example, in allocating costs among various types of users, it is necessary to take into account not only operating costs, but also fixed charges on the plant investment. The plant investment chargeable to each type of user can best be determined from a complete inventory and appraisal of the property or from an accurate record of historical costs. Under public service commission regulation, private companies are required to keep such records. Under municipal operation, they may be incomplete or entirely lacking. In a recent water rate analysis at Greensboro, N.C., a fairly complete record of the plant investment was found. At Raleigh and Winston-Salem, N.C., the records were inadequate, and it was necessary to prepare a very approximate reproduction cost estimate. Historical cost (rather than reproduction cost) less accrued depreciation is favored by most courts and commissions in fixing public utility rates. The reproduction cost method, however, yields a satisfactory base for estimating the relative value of the various elements serving each type of consumer. It may be noted that the results at Greensboro, based on historical cost, were comparable to those at Raleigh and Winston-Salem where reproduction cost less estimated depreciation had to be used.

TABLE 1

Distribution of Consumers and Water Use

Class	Raleigh		Greensboro		Winston-Salem	
	Inside	Outside	Inside	Outside	Inside	Outside
Consumers—*per cent*						
Domestic	83.8	12.7	90.6	6.4	91.9	4.6
Intermediate	2.7	0.4	2.4	0.2	2.9	0.2
Manufacturing	0.4	<0.1	0.3	0.1	0.4	<0.1
Total	86.9	13.1	93.3	6.7	95.2	4.8
Water Consumption—*per cent*						
Domestic	35.9	5.2	38.7	2.5	32.4	1.3
Intermediate	14.4	2.1	13.5	1.0	17.7	0.7
Manufacturing	36.4	6.0	21.5	22.8	45.8	2.1
Total	86.7	13.3	73.7	26.3	95.9	4.1

Finally, consideration must be given to the overall planning and engineering of the systems, with particular reference to possible stage developments in order to keep capital costs at a minimum until the works are needed and increased revenue will be available to finance them. Where utility revenues are not adequate or where

utility surpluses have been tapped for other city purposes, municipal officials nearly always insist upon building generously any major new works. The officials recognize that it is easier to get a large sum of money once than to return in a few years with a supplementary request. This method may be a political necessity, but it frequently eliminates step-by-step developments that would save the citizens money in the long run.

Cost Allocation

Once the total revenue requirements have been established, the problem is to fix rates so that the cost of service will be allocated properly among the several classes of users. It costs less to deliver a large quantity of water to a single manufacturing consumer than to furnish small quantities of water to a hundred domestic consumers. On the other hand, most of the water production costs are dependent only upon the quantity of water, and the same unit cost per gallon should be charged to large and small consumers. The principles followed in cost allocation and some of the problems faced may be illustrated by data developed in surveys at Raleigh, Greensboro, and Winston-Salem. As the Greensboro report has not been made public, and rate matters are likely to be controversial, only a few data from this study will be presented here. The procedure and results obtained at Greensboro, however, were similar to those at the other two cities.

The basic problem in these rate analyses was to break down the cost of providing water (and sewer) service into component parts, which then could be allocated on a reasonable basis among the various classes of users.

TABLE 2

Distribution of Capital Costs

Facilities	Raleigh *per cent*	Greensboro *per cent*	Winston-Salem *per cent*
Supply works & raw-water mains	34.0	33.4	31.0
Filter plant & pumping stations	27.0	22.2	19.4
Transmission mains	14.4	8.9	13.6
Distribution system	24.6	35.5	36.0
Total	100.0	100.0	100.0

TABLE 3

Distribution of Operating Expenses

Item	Raleigh *per cent*	Greensboro *per cent*	Winston-Salem *per cent*
Production	37.5	53.2	38.9
Distribution	52.7	34.9	50.4
Meter reading, billing, & collection	9.8	11.9	10.7
Total	100.0	100.0	100.0

The first step was an analysis of water billings to determine how much water was used by consumers of various classes, inside and outside the city limits. Billings for a year were used except in one city where available data for representative months were substituted. For purposes of this analysis, all consumers were divided into three categories: domestic, intermediate, and large or manufacturing. The limits for each (cubic feet per month) classification were: domestic, 0–3,300; intermediate, 3,300–33,000; large or manufacturing, more than 33,000.

These steps, which compare closely with those recommended by various

rate committees of AWWA and other societies, were used simply to permit the determination of the relative cost of supplying the average domestic consumer and the average large manufacturer. In fixing the schedule, rates were selected which would provide a smooth decrease in unit water costs throughout the normal range of consumption, without reference to the classification.

The differences in the distribution of consumers and water use at Raleigh, Greensboro, and Winston-Salem are indicated in Table 1.

Capital Costs

To determine the cost of serving each class of consumer, it was necessary to break down both debt service and operating expenses into component parts. Debt service was allocated among the several classes in proportion to the value or investment in water works serving each class, according to the following principles:

1. All water users, regardless of size, should share the cost of supply works, pumping stations, filter plant, distribution system storage used for meeting normal peak demands, and transmission mains and principal distribution system feeders. All mains larger than 12 in. and some of the 12-in. mains were included in this category.

2. Intermediate and domestic water users should share the cost of all other water mains 8 in. and larger.

3. Domestic consumers alone should bear the cost of distribution mains 6 in. and smaller.

4. Chargeable directly to fire protection are two-thirds of the elevated storage and all fire hydrants and guard valves within the city. The portion of elevated storage chargeable to fire protection should be shared by all consumers, while the hydrants and guard valves should be charged to inside consumers only. (No attempt was made to segregate accurately other costs chargeable indirectly to fire protection.)

5. The division of capital costs between city and suburban consumers within each classisfication should be on the basis of water consumption, except for fire protection.

6. Fire protection costs should be allocated among all classes in proportion to the number of consumers in each class, weighted according to water consumption. (This was done by taking for each class the average of the percentage of total consumers and the percentage of total consumption.) Some inequities in the allocation of fire protection costs are inevitable. Normally, however, the large water user has an investment in property greater than the ordinary home owner and consequently derives a greater benefit from fire protection.

An approximate percentage breakdown of the capital investment in water works facilities, exclusive of meters and services, at the three North Carolina cities under study is shown in Table 2. These data include proportionate allocations of shop, office, and equipment items, as well as major proposed plant additions. The proposed additions do not include service lines and meters paid for entirely by consumers in two cities and almost entirely in the third. The proposed additions do not include water mains to be installed on a yearly basis from operating revenue. Allowing for this, the percentages chargeable to trans-

mission and distribution systems would be somewhat greater than shown. A significant fact, often overlooked in attempts to set up preferential rates for large users, is that 50 per cent or more of the fixed charges are for water production facilities.

Operating Costs

In allocating water works operating costs among the several classes of users, the following principles were employed:

1. The cost of billing and meter maintenance was divided in proportion to the number of accounts in each class.

2. Water production costs were allocated in proportion to the water consumed by each class.

3. General operating expenses, principally maintenance of the distribution system, were allocated in proportion to the distribution system investment charged to each class of consumer.

4. Distribution system extensions were charged to intermediate and domestic consumers only.

An approximate breakdown of the water works operating expenses in the cities is shown in Table 3. The water distribution expenses include extensions financed by the city out of annual revenues. It will be noted that the amount charged to water distribution in Greensboro is considerably less than that in Raleigh and Winston-Salem. This difference is due to the fact that major distribution improvements are not contemplated and that landowners are assessed for the cost of most distribution system extensions in Greensboro.

Results of Analyses

Although the details of the rate analyses at Raleigh, Greensboro, and Winston-Salem cannot be included here, the principal results and conclusions may be summarized as follows:

1. The water rate to be paid by the average domestic consumer should be 2–2½ times as much as the rate paid by the average large manufacturer. Low industrial rates of less than one-third the domestic rate cannot be justified in these cities.

2. Outside-city consumers should pay from about 50 to 100 per cent more than inside-city consumers for water service. A rigorous analysis shows the outside-city consumers' costs to be somewhat lower than these limits, but intangible factors which cannot be accounted for entirely in the

TABLE 4

Recommended Water Rates at Raleigh

Monthly Use—*cu ft*	Rate—*¢/100 cu ft*	
	Inside City	Outside City
0–3,200	30	60
3,201–15,000	25	50
15,001–50,000	18	36
50,001–500,000	12	24
Over 500,000	10	15

TABLE 5

Recommended Water Rates at Winston-Salem

Monthly Use—*cu ft*	Rate—*¢/100 cu ft*	
	Inside City	Outside City
0–3,400	28	56
3,401–10,100	21	42
10,101–33,500	16	32
33,501–124,300	12	24
Over 124,300	9	18

analysis justify some extra charge. The extra charge to a large suburban consumer should be less than that to a domestic suburban consumer because of the lower cost of water delivery and distribution to the former.

The water rates recommended at Raleigh are shown in Table 4. The average cost of water under the old and under the recommended schedule is shown in Fig. 1. It will be noted that the relative cost to domestic and large users has remained substantially the same. The old rate covered both water and sewer service, without a surcharge. The proposed combined rate, with a sewer service surcharge, represents a 40 per cent increase.

Water rates recommended at Winston-Salem are shown in Table 5 and are compared with the old schedule in Fig. 2. Recommendations to the three cities also included a graduated minimum charge, varying with meter size, and special charges for private hydrants and sprinkler connections.

Special Considerations

Some situations require special consideration in fixing rates. For example, a large industrial consumer may want to purchase raw water. At Charleston, S.C., a paper company takes 30 mgd of raw water from the municipal system. The company's use is nearly twice the total consumption of the rest of the city. This is obviously a special case, requiring particular treatment. In any event, a city should be careful not to commit itself to the sale of so much low-cost raw water that it will be obliged to seek a new and perhaps expensive source of

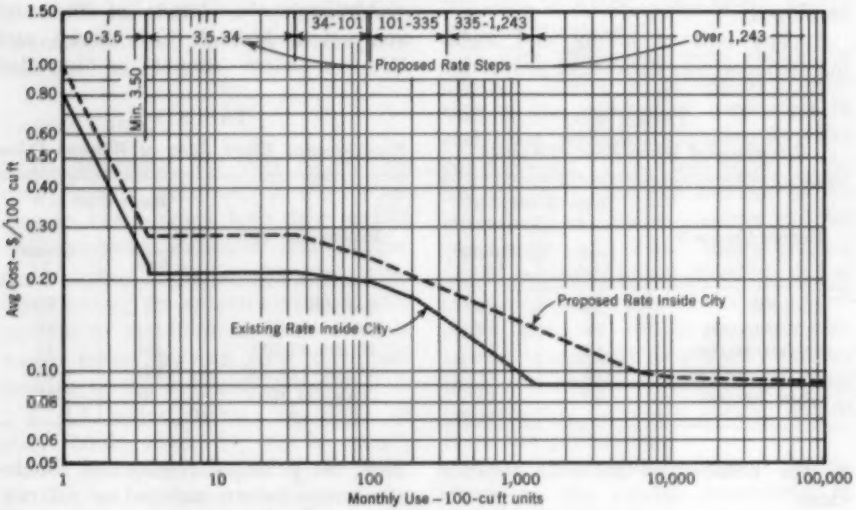

Fig. 1. Proposed Rate Schedule at Raleigh

Existing and proposed rate schedules are compared.

supply at an early date. The raw-water price should be high enough to pay a substantial part of necessary additional development.

There is a growing movement for higher rates to cover water used for sprinkling and air conditioning. The basis for the extra charge is that these demands are limited to a few hours each day during summer. The facilities needed to supply the peak demands pays for extensions. If all or part of the cost of extensions is assessed against the property, the cost of water distribution is proportionately less, and the domestic and manufacturing rates should be more nearly equal.

The allocation of costs to serve outside-city consumers is not entirely satisfactory. There is plenty of justification for higher rates outside the city, but sometimes the burden on the

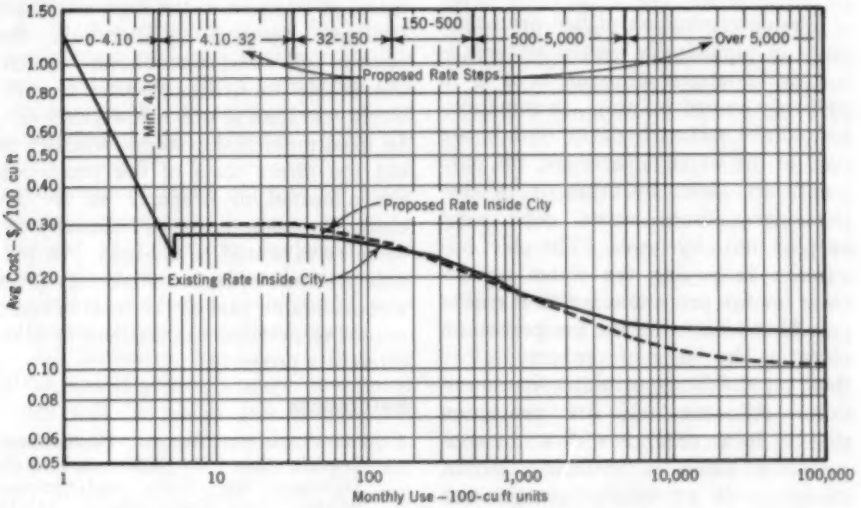

Fig. 2. Proposed Rate Schedule at Winston-Salem

Existing and proposed rate schedules are compared.

are relatively large in comparison with the total consumption and revenue. The more homogeneous a community, the less justification there is for special rates. The development of an inexpensive water demand meter unquestionably would foster the adoption of demand charges similar to those in the electric-power industry.

Water rates must take into account whether or not the property owner outside home owner is excessive. This is particularly true where the home owner pays for all of the water and sewer lines, either in the purchase price of his house or through assessment, and his area is annexed by the city within a short time. In such cases, the city usually acquires the utilities at no cost, and the suburban home owner is at a distinct disadvantage compared with a person who builds a

house within the city limits. Most municipal authorities agree, however, that the suburban owner enjoys benefits far in excess of what he pays through extra charges for water, sewer, and other services. These benefits usually cannot be measured accurately, but they contribute to the feeling that substantial surcharges for outside-city customers are justified.

Fire Protection Charges

The determination of fire protection costs in municipally owned systems is not as important an issue as it is in privately owned utilities. In some municipalities where hydrant rentals are paid to the water department, the payments are offset by taxes or by disbursements from water department surplus into city funds. The chief advantage in paying the water department for fire protection is that it makes possible allocation of the fire protection costs on the basis of property rather than on the basis of water consumption. Allocation of fire protection charges in accordance with water consumption alone is obviously unfair, except in an extremely homogeneous community. The inequities are apparent from a comparison of a laundry, which uses a great deal of water, with a sawmill or furniture factory, which uses practically no water at all.

In recent years peak water demands have become high in relation to average demands. Many distribution systems are loaded to capacity in the late afternoons to meet heavy sprinkling demands. At such times there is little reserve in the distribution system for fire protection, and chief reliance is put on the fact that other uses will be curtailed in the event of a large fire. Few cities have built up their distribution systems to provide for peak fire demand in addition to the high afternoon ordinary demands. Therefore, the portion of the distribution system chargeable to fire protection is relatively less than it was a few years ago. In most municipal systems, whether or not the direct costs of fire protection are allocated to property or are included in water rates, substantially the same rates would be charged. In private systems, hydrant rentals may form a considerable part of the total income, requiring detailed calculations to allocate costs properly.

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City Planning and Water Works

George C. Ahrens

A paper presented on Oct. 14, 1954, at the Iowa Section Meeting, Cedar Rapids, Iowa, by George C. Ahrens, Supt., Water Works, Ottumwa, Iowa.

THE greatest challenge that exists in this country today for water works men, engineers, designers, builders, real estate developers, and city planners is that of saving the nation's cities from decay. America's cities are being permitted to die slowly. The investment of labor and capital made by past generations is going to waste because of failure to modernize the older areas and to control adequately sanitation and other problems of suburban or fringe area development.

An authority has stated that by 1963, unless action is taken now, most cities will be places few people will want to live in, work in, or even visit. It has also been said that the greatest city in the world, New York, is being permitted to decay and go bankrupt. New slums are being created faster than old ones are being eliminated.

If the disintegration and economic blight of the nation's cities are to be prevented, facts must be collected and analyzed, in order to formulate a plan that will control future development, stimulating or retarding it as required.

Objectives of Plan

1. City planning should have as its chief object the avoidance of costly reconstruction.

2. A reasonable plan, once decided upon, should be adhered to in its essential features. Demands for departure from it are likely to be encountered from those who are actuated by selfish interest or who are unable to look beyond their own limited horizon.

3. The city plan must supply an objective towards which the city may grow. It is not something to which the city must be restricted or within which it must be confined. With a plan, there is no such thing as a big job. Any job, regardless of size, can be broken down into smaller tasks, which will complete the larger work in accordance with the overall aim.

4. The plan must be the key to the community's future. When a long-range program is laid out to be worked toward, with the cooperation of city officials, engineers, utility companies, contractors, and others, the need for speculation about future development is completely eliminated and the way is cleared for the best possible use of community dollars and facilities.

Streets

The modern city owes its growth and prosperity to its facilities for internal communication. A heavy penalty must someday be paid for the lack of an orderly arrangement or system of main streets. Costly street widenings and construction of new street connections inevitably become necessary.

The chairman of New York City's board of transportation has stated that if cities are not freed from traffic strangulation soon, there will be no

cities; they will become ghost towns. Vehicle registrations are increasing at the rate of 3,500,000 a year. Adequate parking facilities are extremely important. Making it easier for the motorist to park his car is as important as providing the streets leading to the downtown area.

A recent survey made in eighteen cities, most of them with less than 100,000 population, showed that the average value of a single parking space in terms of retail sales produced was at least $20,000. Silver Springs, Md., with 75,000 population, has added 2,000 off-street parking spaces since 1945, resulting in a fivefold increase in real estate values.

The cost of pickup and delivery truck operation is said to average 5–10 cents per minute. Thus, a 10-min delay due to driving around the block to find a place to park may add $1.00 to the delivery cost.

Traffic congestion is the most serious single problem of the cities. The life of a city is as dependent upon the adequacy and efficiency of its streets and traffic system as the human body is on the proper circulation of its blood.

Zoning

Zoning for density of land use makes it possible for water, sewer, gas, electric, and telephone utilities to plan future extensions of service in an orderly and economical manner. Where there is no plan, the utilities are in difficulties. They cannot tell how much electricity, gas, and water must be provided at some future date.

Cities must plan for the development of factory areas with at least as much care as they use in planning for areas of single or multiple dwellings. Planners must recognize that industry creates the economic base necessary to finance the construction of a beautiful city. Industrial districts must be stabilized by providing sound neighborhood plans and zoning regulations. The mistake of putting gracious living ahead of the economic means of life must not be made. It is highly important that potential industrial ground should not be rendered sterile through encroachment by so-called higher types of development. Conversely, a well developed residential area should not be encroached upon by industry.

If there is to be a real park system, it must be designed comprehensively to fit in with all the other elements of the plan. Land which in time would make the best parks is often passed over as unsuitable for construction because of high development costs due to steep hillsides, creeks, meadows, and woods. The city must be ready to take advantage of unexpected opportunities to acquire such land or to correct defective conditions at a minimum of expense.

Public buildings should be located where the conduct of public business is convenient. Their design and construction should give a favorable impression to visitors.

Fringe Area Growth

Fringe areas and suburban developments have grave sanitation problems. Typhoid fever has been eliminated from municipal water systems, but still persists in outlying areas.

The mayor of Modesto, Calif., has stated that his city is a good example of unplanned sprawl. It is an urban community of 55,000 people, more than 35,000 of whom live outside the city limits. The suburban area has devel-

oped without a plan, without zoning, and without building standards. The 35,000 suburbanites have no sewers, limited police and fire protection, essentially no parks, and no street lighting. Imagine 35,000 people without a sewer system, 10,000 septic tanks and cesspools in a modern urban community! Modesto and the suburban areas now have a joint rehabilitation program.

These conditions arose as the result of piecemeal and haphazard development by promoters for quick profit. Money was made at the expense of the city which was expected to provide water and other services. Lack of proper planning results in problems and higher taxes when the mistakes which could have been avoided have to be corrected. The city and the suburb must find some way to equalize financial burdens and to plan jointly for the area in which they both belong.

The growth of cities may be compared to that of the iris plant. If a single iris is planted and allowed to grow unmolested, in a few years it will have branched out and become a large, round clump. In time, however, the old bulbs or rhizomes pile up in the center and decay, while about the periphery new irises continue to extend the circle. Many cities are in this condition today, spreading out over new areas while the center rots.

William Zeckendorf, a prominent figure in the real estate world, in an address to the Harvard School of Design, at Boston, Mass., made these statements: "Here is a city in which there are five billion dollars or more invested. Try to save it from disintegration and economic blight, [a sure result] if you do not do something about the core which you are permitting to rot. If a city grows at its edges and nothing is done to rehabilitate the central area, only municipal bankruptcy [lies] ahead. Our firm is so concerned about Boston that it would not buy any real estate here. We believe that Boston, with its high tax rate, is going to go broke."

Rehabilitation

Ten years ago Pittsburgh, Pa., was the dirtiest city in the United States. The air was polluted with smoke, traffic was snarled, low ground was constantly being flooded, and industry was moving away. Then came the "Pittsburgh Plan," concerned with the redevelopment of the downtown section called the "Golden Triangle."

Richard Mellon was the man responsible for the Pittsburgh rehabilitation, by inducing private capital to cooperate with the city government. Business is no longer leaving, but is moving into Pittsburgh. Floods have been reduced by upstream dams. Other cities are asking what suddenly happened to Pittsburgh.

Other outstanding examples of redevelopment are Cleveland, Philadelphia, and Chicago, each with a total of $200,000,000 in projects. The slum-clearing programs of Baltimore, Indianapolis, and Milwaukee, along with the smog cleanup campaigns of Pittsburgh, St. Louis, and Los Angeles, are other instances. Boston has started a $200,000,000 redevelopment project for the downtown area.

Because of the decay and obsolescence that have been permitted to develop in American cities, over one-third of the nation's families are living under conditions below modern health and sanitation requirements. Certainly, no one wants to go back to the

days when typhoid fever, dysentery, and summer diarrhea were commonplace. Yet in many areas there is being created the very environment in which these diseases once flourished.

The basic shortcomings of cities as places for family living are that many sections are ugly, worn out, run down, or just drearily monotonous. Lots are too small for a game of croquet or even a modest flower and vegetable garden. Houses are too close together for privacy or safety from fire hazards. City blocks are too small and residential streets carry too much traffic, with all its noise, fumes, and danger to life. Little allowance has been made for neighborhood playgrounds.

American cities do have many good features, and great improvement can be accomplished through simple face-lifting procedures. Structurally, houses today are not very different from those built 200 years ago. Well built and well maintained houses do not lose their usefulness in 25 or even 50 years. Neighborhoods deteriorate largely because of indifferent maintenance owing to lowered living standards. Areas depreciate because of the intrusion of such undesirable elements as shops, taverns, gas stations, or overcrowded dwellings, resulting from unjust tax schedules and zoning classifications.

If deterioration has not gone too far, many neighborhoods can be reclaimed and made attractive. These areas may retain their residential values for years with some repairs, remodeling, painting, and planting of trees and shrubs. Some neighborhoods can be given a new lease on life by condemning the most substandard block of houses and replacing them with a park and playground.

Cities must be made and kept attractive and efficient, for the largest portion of the inhabitants of the United States live in urban areas. One hundred years ago less than 5 per cent of the population lived in cities. Fifty years ago the urban population was only 20 per cent. Today 100,000,000 people, 65 per cent of the nation's population, are concentrated in urban areas.

Conclusion

Municipal planning must cover streets, zoning, parks, civic centers, fringe area development, and rehabilitation if city living is to be convenient and dignified. Congestion makes life in the city expensive, difficult, uncomfortable, and inefficient. Ugliness follows disorderliness.

Of particular concern to water works men is the establishment of criteria for land development which will help them plan future extensions. From a zoning map, the population density for each area can be determined. Manufacturing and industrial areas can be permanently established. The major-street plan will indicate the location of future street extensions and right-of-way widths. By means of this information, water main extensions can be efficiently planned, with the assurance that they will serve future needs. The mains can be properly located, to avoid costly future construction.

Water works men are associated with important elements of city planning. Their professional advice is needed in deciding which areas should be developed first to make the most economical use of existing facilities. From the standpoint of the future welfare of a community, the water works undertaking is a most important one, because, next to air, water is the most precious commodity available to man.

Management Attitude Toward Safety Engineering

Kenneth N. Beadle

An address presented on Oct. 29, 1953, at the California Section Meeting, San Francisco, Calif., by Kenneth N. Beadle, Director of Safety, Pacific Intermountain Express Co., Oakland, Calif

SAFETY engineering is a vital subject, and one that should be of primary interest to management. Unfortunately, all too often this group has a short-sighted attitude toward safety engineering. My purpose is to help elevate the level and importance of the field of accident prevention, and to motivate action among those of you who can do something about its position and status within your organizations.

Although I am attempting to stress accident prevention, do not forget that good employee relations are an essential requisite for harmony in any organization. It has been said that you can buy a man's time, but his loyalty and enthusiasm must be inspired. With the foundation of good employee relations and the practice of wise public relations, you will be provided with some of the basic tools for safety engineering. Having an employee satisfied is tantamount to having him perform safely.

Some companies, when confronted with a cost curtailment program, begin by lopping off safety activities. This is hardly a proper application of the principle of "safety first." Ironically, this type of alleged cost control actually cuts off the most profitable activity on the books. Needless accident costs are staggering—especially those which do not appear on paper. The kind of management that is blind to the need, purpose, and function of safety engineering hurts industry and is damaging to the whole American economy.

I would like to tell you something about my firm's experience with a safety program. Between 1946 and 1952 the company was able to reduce its total vehicle accident costs while increasing its road miles 150 per cent. This meant that, in cutting over-the-road accident rates by more than 50 per cent and city fleet accident rates by more than 75 per cent, management was also able to reduce its ratio of loss to gross revenue by approximately 75 per cent.

If you assume that this came about by chance, or was the product of special financing, you are mistaken. You will agree, I am sure, that I have some evidence to prove that I am not just theorizing about cutting accident costs.

It is up to management to push a safety program forward. To my knowledge, in every organization where there have been successful results the top man has either initiated the program himself or was actively motivated by the promoter.

Industrial injuries and the cost of workmen's compensation are a major expenditure in many organizations. Yet some are apparently oblivious to

the fact that something can be done to reduce this cost, and that the dollars spent on one serious injury claim could have been used as salary for a man placed in a position to prevent many more needless injury costs.

I am not talking about a man who hangs up safety posters. That ancient concept of a safety engineer unfortunately still exists in the minds of some uninformed and unintelligent members of management today. It is, perhaps, a carryover from the days of the uneducated and untrained safety man in the blue shirt, suspenders, baggy pants, and old hat who walked around trying to find something wrong wherever he went.

At the close of 1949 a loss ratio of 62 per cent in workmen's compensation presented my company with a challenge. It meant that $53,000 had been spent to pay for occupational injuries—not premium, not intangible costs—just medical bills and compensation payments. At the end of 1952, my firm had 520 more employees than in 1949, but the loss ratio was 19.7 per cent. From a direct cost of $53,000, the figure had dropped to $25,000, and the cost per employee had fallen from $36 to $13. This experience indicates that management can afford to have someone on the payroll for safety activities.

Important Questions

Do you know exactly the amount of money workmen's compensation is costing you? Do you know whether your company rate is lower or higher than the average rate for the industry in your state? What is the trend of your loss ratio—up or down? Have you examined your workmen's compensation setup to determine whether you should be self-insured or should buy insurance? If you are buying it, are you buying it correctly? What are you doing about industrial accident prevention? Is it merely lip service, or do you administer a specific and workable program of activities, with full-time promotion, education, and supervision for the prevention of occupational injuries?

Safety is not free of cost. Selling or teaching safety requires a sound, well planned, and comprehensive program of education. I have yet to find education free of charge.

There is far too great a tendency to accept the inevitability of accidents, and not enough resolute decision to employ concerted preventive measures that can stop most mishaps. Safety is said to be a matter of common sense, but there is a percentage of the populace that does not have common sense. If accidents are recorded as carelessness, that tells nothing. It is an alibi that precludes thorough investigation, closes the door on accurate analysis, and prevents knowing the real cause. It must be noted who was careless, in what way, and why.

Conclusion

In the final analysis, management policy and its enforcement determine accident and injury loss ratios. When operating costs are subtracted from revenue, and the figure that is left seems too small, take another look at the expenditure for accidents, from which you get no return. This deplorable expense is created by blunders erroneously called accidents.

An enlightened management has proved, and will continue to prove, that safety engineering, if it is also sound human engineering, is an integral part of, and fundamental to, efficient operation in any industry.

Considerations in Water Works Safety

Wendell R. LaDue

A paper presented on Nov. 9, 1954, at the West Virginia Section Meeting, Huntington, W.Va., by Wendell R. LaDue, Chief Engr. & Supt., Bureau of Water Supply, Akron, Ohio.

EACH year there are impressive and shocking statements to the effect that public employees represent the largest single group in the United States not subject to formal safety standards, regulations, and programs. Quite obviously, and fortunately, there are outstanding exceptions to this generalization, particularly among water works. These exceptions, however, point out forcefully the widespread need for positive action. The water works industry realizes that it is obligated to do everything within its power to prevent employee accidents and attendant suffering. Surely the industry will not long tolerate unsafe working conditions, unsafe supervision, or unsafe personnel. Good planning will eliminate the physical hazards of the job, but human engineering alone will create the desire in the individual to acquire a safe work philosophy expressed in safe work habits.

In December 1950 a group formerly known as the Public Employee Safety Committee took its place among the 25 industrial sections of the National Safety Council as the Public Employee Section. Thus, federal, state, county, and municipal officials concerned with employee safety now have representation in the organization, and the public employee has gained official recognition in safety affairs. The importance of this step may be more fully appreciated when it is realized that about 6,000,000 public employees are involved.

Water works men are not only public employees but also public utility employees. In the National Safety Council, there has existed for many years a division known as the Public Utilities Section, composed of groups representing the power, communications, and gas industries. In 1952 the water utilities received further assistance by being added to this section, thus gaining the accumulated knowledge of the group, as well as the prestige accompanying utility recognition.

Need for Coordination

Water works employee safety has not been a problem of inactivity but rather one of lack of coordination. In those few cities which have safety programs, water works activities are usually compared on the same basis as industrial plants. No water utility official can justify, year after year, permitting employees to suffer 3–30 times the number of disabling injuries that are suffered by a like number of employees of a well managed private industry. Statistics now available would indicate that such a condition does exist. Injury record systems are not yet in vogue in enough water utility units to provide complete verification. Some

cities have excellent programs, notably San Diego and Oakland, Calif.; Detroit; Cleveland, Ohio; Baltimore; and New York, Akron, Ohio, has a plan 15 years old (*1*).

Full opportunity must be given for employees to take a prominent place in the operation and application of a safety program. Management must be awake to this possibility as old and new employees alike come forward to learn new and improved methods for their own protection. Safety is not a one-shot affair, but the results of a well thought-out plan. Water works operations are similar to those of other industrial establishments, and there is no valid reason not to use well known and long established means of employee protection. Nor is there any doubt that an individual water works can do an outstanding and effective job in its own sphere of activity if its management will take the time. Better results could be produced, however, if the safety program received stimulation from group effort, from opportunities for comparison with others in the water works field, and from pooling of experiences and ideas.

Water works have been slow in applying and recognizing the benefits of a comprehensive safety program. Only the individual water utility itself can say why. If a generalization is justified, however, it is that water utility agencies, like small industrial plants and service organizations, have been slow to grasp the relationship of active safety programs to both economy and efficiency of operation.

Water works are not unaware of the problem, but, in the main, they have been acting like small industries. To put it another way, most of the successful accident prevention programs are those carried on by large private employers. The reasons for this situation are too complex for discussion here. Competitive pressure is obviously one factor, and centralized control and authority is another. Modern cost-accounting systems are also a factor, as are legislative and union pressures. The fact is, big private industry has a virtual monopoly on permanent and effective safety work. Small industry (of which the water industry is a part, even though, paradoxically, it is collectively big business) must and will learn that safety is a necessity.

Stimulation of Interest

Apathy on the part of a water works can be changed to active interest chiefly by positive, insistent demand from the top executive management. It is an axiom in the safety field that an organization has no more employee injuries than top management will allow. It is extremely important for the employee to have the right attitude toward safety. Management has the responsibility to do everything possible to see that he has that attitude. If top authority shows no regard for the safety of employees, unsafe conditions will exist and inevitably breed employee injuries. Neither the public nor utility employees can be expected to be deeply concerned over the prevention of accidents unless management officials are, too.

A good safety program is an element of successful business. It will force recognition and acceptance upon any manager. It is just as important as selecting a proper source of supply, finding a suitable plant site, hiring proper personnel, or purchasing necessary tools, equipment, and materials. Positive recognition and interest shown by the chief executive of a water utility will, of course, be translated into

equally active interest on the part of supervisors through the usual channels of training, upgrading, persuasion, and other devices by which executive orders get carried out.

Apathy can be changed to active interest through the many types of activities which go into a good safety program. The specific procedures and materials for creating and maintaining interest in safety are available from the National Safety Council, insurance companies, and the US Dept. of Labor, and will soon be published in the manual developed by the Safety Committee of AWWA.

Value of Safety

Safety programs are obviously good business for water utilities. Otherwise, the wealthiest, most powerful, most competitive industries in the world would not be supporting such programs with large budgets for setting up safety departments, hiring trained personnel, and insuring safe procedures in industrial processes.

Furthermore, safety programs provide good employee relations, good public relations, and good protection against legislative control. A man who has his house in order need not fear the approach of authority to make it so. This is something more than humanitarian interest. The experienced utility manager knows that safety is good business. He realizes that the establishment of policies, procedures, and practices for the safety of employees is a primary responsibility of management, and that safety is not to be sacrificed or jeopardized in any way by loose thinking or inertia.

Accident Classification

Accidents may be classified by cause, the categories differing with the individual water utility. Such an analysis should be one of the first steps in a safety program, as the results will show where an accident prevention effort is most needed.

The difference between a minor injury and a severe one may include an element of chance. It is important that the facts of each accident be obtained. Descriptions of procedure on cause analysis are available from safety agencies. Cause classifications are not difficult. They consist chiefly of common-sense breakdowns of actual case histories, indicating the unsafe acts and conditions which cause the most frequent or the most serious injuries. Remedial measures are more readily administered with such cataloging. For example, if many meter readers are bitten by dogs, a remedy can be sought. If one meter reader is bitten by many dogs, another meter reader may have to be sought. All employees would not have the same responsibilities for achieving safety, but each would have some responsibility.

Small-Utility Programs

A safety program can be applied by small utilities which cannot afford a safety director. Safety is not necessarily a specialty; it is generally a product of common sense. Almost any competent administrator or department foreman knows enough about how to do the job right, and safely. Safety, in its essence, is simply doing an operation correctly and under control. Accident prevention is nothing more or less than the control of an operation, which likewise involves control of persons and their potential unsafe acts. It is part of a well organized plan of procedure.

Small utilities are not doomed to have high injury rates. Again, it is

a matter of control, sometimes very personal, but results can be accomplished. Small plants—those with fewer than 500 employees—at present have about 2½ times the injury rate of large plants. The cause is failure to act rather than inherent difficulty. This point has been proved many times by the success that small enterprises have had in controlling their injury problem when the management recognized the problem, analyzed the causes, developed a solution, and acted vigorously and intelligently. Safety is not so intangible that it cannot be achieved, nor need it be expensive.

Elements of Safety

According to the National Safety Council (*2*), the basic elements of safety organization, which can be readily applied to a utility, are:

1. *Management leadership.* This requires assumption of responsibility and a declaration of policy by the chief executive or manager.

2. *Assignment of responsibility.* If the chief executive cannot personally take charge of the safety program, he should make someone else responsible and give him time and full authority to do the job.

3. *Maintenance of safe working conditions.* This involves the correction of known unsafe working conditions and the provision of personal protective equipment where such conditions cannot be wholly corrected.

4. *Safety training.* Supervisors, however well trained in their jobs, are not fully capable unless they know how to handle people. Workers need to know the elements of their jobs, particularly the simple ones which so often are taken for granted.

5. *Accident records.* The administrator must know enough about what is happening and how it is happening to make the safety effort intelligent and effective. These records should be made available to all.

6. *Medical and first-aid care.* A good safety program involves placement examinations, the treatment of injuries, and health care.

7. *Acceptance of personal responsibility by employees.* This involves not only job training but the creation of interest in the safety program on the part of employees. Interest is very necessary, because safe practices will not be followed by an unwilling employee and cannot be enforced adequately by supervision.

The water industry is not now a relatively safe field. The 1953 record compiled by the National Safety Council shows an accident frequency of 23.19 for water works and a severity of 0.93. These figures can be taken only as an indication, because not many water departments compile and report standard frequency and severity figures. It is reasonable to assume, however, that more data would not decrease either rate materially. Organizations which have enough of a safety program to keep such figures and report them to the National Safety Council (presumably as members) generally have a better injury experience than enterprises which do not compile or report accident statistics.

AWWA Activities

One association which has shown more than usual interest in the development of safety operations among its members is AWWA. Perhaps more than any other group, including government agencies, it has printed safety articles in its national publications, collaborated in planning safety work, and shown its willingness to further a

safety program. At the January 1950 meeting of the Board of Directors, the author, as chairman of the Committee on Water Works Administration, directed the Board's attention to the general lack of safety programs among water works. He stated that this subject would receive intense committee attention during the 1950 Conference. At the January 1951 Board meeting, a task group was set up to study the problem. The group report at the 1951 Conference was met by unusual and extended floor response.

At the January 1952 Board meeting, the author obtained approval for the establishment of four task groups to study and report on safety practices in: [1] supply; [2] treatment and pumping; [3] distribution; and [4] administration. Personnel of these groups are now actively engaged in safety studies. Much concrete evidence of progress was reported at the 1953 Conference, and a safety manual was proposed. No recent AWWA activity has brought forth greater spontaneous membership participation. The manual will be published during 1955. Although it will fill the need for an authoritative approach to the water works safety problem, the most valuable result will be the building up of safety consciousness among the employees of water utilities everywhere, and especially among the members of AWWA.

Conclusion

The president of the National Safety Council, N. H. Dearborn, said recently that safety is a race, an unending competition in which man must everlastingly learn new methods to deal with new problems which his own ingenuity has created. In industrial employee overturn, personnel will be lost, new men will be employed, and new problems will develop, while old ones remain. Utilities can ill afford the loss which accidents will bring, especially at a time when good employees are hard to find and harder to keep.

Human error, or lack of regard for the obvious, is said to be the most important contributing factor in accidents. Man knows the techniques of safety, but he lacks the will and the self-discipline to maintain the proper attitude toward safety. The success of numerous industries in reducing work injuries proves that the application of known preventive methods by utility personnel and management working together can materially reduce employee accident tolls. The author believes that the immediate need is to obtain and disseminate better knowledge of the types of accidents, as well as information on their cause and control. The activities which are being undertaken by an increasing number of cities in cooperation with the National Safety Council and the AWWA will fill that need.

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Infestation of the Norwich, England, Water System

S. N. Kelly

A contribution to the Journal by S. N. Kelly, Engr. & Mgr., Water Dept., Norwich, England.

THE city of Norwich, in Norfolk, England, obtains its water from the Wensum River, a sluggish stream draining about 256 sq miles above the point of intake. The catchment area, although studded with small towns and villages, consists principally of agricultural land. The water works supplies not only the city but also an adjacent rural area of 166 sq miles. In addition, bulk supplies are provided for a rural area of 122 sq miles. The total population using Norwich water is about 180,000. The average demand is 5.5 mgd (Imp.)* with daily peaks of 7.5 mgd.

Treatment of raw river water is partly by slow sand filtration and partly by rapid sand filtration, used in parallel and not in series. Six slow sand filters receive water that has been chlorinated and subjected to several days of plain sedimentation. Treatment prior to rapid sand filtration consists of chlorination and a period of sedimentation assisted by coagulation with aluminum sulfate.

The slow sand filters are carefully maintained with the sand having an average effective size of 0.243 mm and a uniformity coefficient of 1.73. The sand varies slightly in size from filter to filter. Following filtration, all water is again chlorinated and, prior to being pumped into the distribution system, passes through a small tank in which the period of retention varies from about 5 to 30 min, according to the rate of pumping.

Nais Worms

In June 1953 one of the water department's employees, who was engaged in routine main flushing at the village of Coltishall, observed a number of small, white worms in the glass jar used for collecting test samples. The worms, about 1 cm long, were quickly identified in the department's laboratory as *Nais*, a member of the Naididae family of worms and fortunately not parasitic to man or animal.

The presence of the worms at Coltishall made it immediately necessary to determine the extent of the infestation. Systematic flushing quickly showed that *Nais* was present in virtually the entire area supplied. The flushing also revealed the presence of *Cyclops* and *Daphnia*, but not in sufficient numbers to constitute a nuisance. On the other hand, the *Nais* population was so great that, at almost all flushing points, it was impossible to fill a small glass jar without finding several specimens. Curiously, however, there were only three reported cases of worms emerg-

*Further gallonage figures refer to the Imperial gallon; 1 gal (Imp.) equals 1.2 gal (US).

ing from consumers' taps. This was probably due to the fact that service connections are placed at the top of the mains. *Nais* worms tend to remain on the pipeline bottom until stirred up by high velocities.

Source of Infestation

As soon as the widespread presence of the worms in the distribution system became known (and simultaneously with main cleansing measures), a search for the source of infestation was commenced. Because there were no ball hydrants * in the distribution system, it seemed certain that the organisms must be coming from the treatment works or from a leakage of surface water into the covered service reservoirs.

Microscopic examination of centrifuged samples taken from the various filter outlets soon established that immature *Nais* worms were passing through the slow sand filters in very considerable numbers, but no specimens were found in samples from the rapid sand filters. Thorough examination of all service reservoirs showed these to be in excellent order, with no possibility of contamination from surface water.

The immature *Nais* specimens found in the slow sand filter effluent were visible to the naked eye as tiny particles, unrecognizable as worms until examined under the microscope. A few specimens of *Cyclops* and *Daphnia* were also found in this effluent.

Microstrainer Use

At an early stage in the investigations the authors consulted the firm of Glenfield and Kennedy of Kilmarnock, Scotland, on the possibility of using microstrainers to clear the filter effluents of the various organisms. The reply was favorable, and, for experimental purposes, a small microstrainer cylinder, of tightly woven stainless-steel fabric, was provided. The cylinder was 2 in. in diameter and 6 in. in length, and was open at one end.

For 18 months this cylinder was employed in the examination of filter and laboratory tap water. The technique used was to pass about 50 gal through the fabric, wash back the catch with a flow of water from the outside of the cylinder, and examine the deposit from the centrifuged wash water. The results of the examinations of both the filter and the tap water have been informative.

The slow sand filter effluent catch at first consisted almost entirely of *Nais* worms with a few specimens of *Cyclops, Daphnia,* and diatoms of various kinds. In August 1953 nematode worms, typed by the British Museum as *Trilobus gracilis,* made their appearance. These were followed in October 1953 by considerable numbers of rotifers and a few specimens of a flat worm, *Stenostomum.* At about this time the *Nais* worms began to die out, and only a few isolated specimens have since been found. Rotifers have, however, continued to be present in considerable numbers, with nematodes nearly as numerous. *Cyclops* and *Daphnia* occur in small numbers, with a few diatoms present in the months when algal troubles are usually at their height.

The rapid sand filters have yielded only a few diatoms. From the laboratory tap water, the catches have consisted almost entirely of dead rotifers, with a few dead *Cyclops* and

* A fire hydrant controlled by a valve whose outlet is closed by a wooden or rubber ball held against the seating by water pressure.

Daphnia specimens and, at times, diatoms. Virtually no *Nais* have been detected in the laboratory tap water, undoubtedly owing to their disintegration under heavy chlorination.

Corrective Measures

At an early stage in the laboratory experiments it was found that *Nais* readily succumbed to 1 ppm of chlorine. Accordingly, the measures taken to clear the distribution system were careful flushing and stepping up the terminal dose of chlorine to give a residual of about 2 ppm in the mains. Especially heavy chlorination was used at night in mains of districts where disinfestation proved difficult. For flushing purposes, the service area was divided into eighteen sections. One man was employed to flush all hydrants in a section repeatedly, in a fixed rotation.

After about 3 months it was found that the system was clear. Normal flushing routine was then resumed. and the terminal chlorination was reduced to give a residual of 0.5 ppm in the mains. Pending completion of remedial works described later, this dosage of chlorine is to be maintained. It will be increased if there is any evidence of further outbreaks.

Since clearance of the system, only a few isolated cases of *Nais* have been reported. These reports have been followed by vigorous flushing action in the area concerned, with satisfactory results.

Laboratory Studies

Fully grown *Nais* worms, as seen under the microscope, are slow moving, segmented, unpleasant looking creatures. Their presence in a public water supply, even though they are harmless, is of considerable concern. Probably their most objectionable feature is the clearly visible alimentary canal. The bristles are also objectionable. Very young specimens are covered by pinkish spots. The specimens examined have varied in width from 40μ to 200μ. Breeding is by budding and splitting.

Studies under the microscope have shown that fully grown *Nais* worms die and disintegrate in less than 45 min in water containing 1 ppm chlorine. It was the unpleasant sight of the disintegration products which was largely responsible for the author's conclusion that physical removal of the organisms from plant effluents containing them was highly desirable.

It has also been found that a 1 per cent solution of common salt readily kills *Nais,* as does a solution of 30 ppm aluminum sulfate in distilled water. It is believed that the disintegration of the organisms when treated with these reagents takes place because of osmotic pressure.

The nematode worms encountered look much simpler and less objectionable than *Nais.* They are not segmented and are very vigorous in their movements. Like *Nais,* they are not parasitic. They are much smaller than *Nais,* and it is unlikely that a fully grown specimen in a glass of water would be recognized as a worm. The specimens examined have varied in width from 6μ to 60μ. They are oviparous, the eggs being from 60–70μ in length.

Nature has provided fully grown nematodes with a tough, elastic cuticle, which makes them very resistant to chlorine. As much as 20 ppm takes 2½ hr to kill them. Small, immature specimens, however, succumb to 3 ppm chlorine in about 1 hr. They do not disintegrate quickly when killed. Like

the *Nais* worms, nematodes may be killed in the laboratory by a 1 per cent solution of common salt and by 30 ppm aluminum sulfate in distilled water.

Rotifers, like nematodes, are unlikely to be recognized as such if observed in a glass of drinking water. They are readily killed by 1 ppm chlorine and by the other reagents mentioned above. They do not quickly disintegrate when killed.

No special studies have been made of the flat worm *Stenostomum* or of *Cyclops* and *Daphnia,* as these organisms have been present only in very small numbers It has been found, however, that all are readily killed by 2 ppm chlorine.

Plant Tests

The underdrainage systems of two slow sand filters were treated by digging 64 holes down to the gravel. Sufficient sodium hypochlorite was poured into these holes to give a theoretical chlorine dosage of 100 ppm when the underdrainage system was backcharged. Then the filters were backcharged and placed in operation. The water was supplied through a temporary pipe from the rapid sand filters. This experiment was unsuccessful; within a few days both slow sand filters were again passing *Nais* worms in considerable numbers.

Another experiment was to treat the water entering the sedimentation basin, and to feed the slow sand filters with 5 ppm copper sulfate, in addition to the normal dosage of 2 ppm chlorine. This also was unsuccessful, possibly on account of the hardness, which averages about 300 ppm. No plant-scale experiments were tried with common salt as it was not clear how such treatment could be introduced as a routine measure.

When *Nais* ceased to pass through the slow sand filters and rotifers became the predominant offending organisms, prechlorination was stopped for several months, in view of a possible detrimental effect on the filter mat. This also was completely unsuccessful as it allowed rotifers to continue to pass through in considerable numbers. Careful examinations of all slow sand filters while being cleaned and scraped failed to reveal any way in which raw water could be short-circuiting the sand beds.

In the light of the laboratory findings, a perplexing feature of all the investigations made was the failure of prechlorination to eliminate the various organisms, with the possible exception of the nematodes. The author is unable to offer any reasonable explanation for this anomaly.

Long-Term Remedies

Most of the work described was done within 3 months of the discovery of the outbreak of *Nais* worms. It was obviously necessary that during these early stages a scheme should be prepared to prevent a recurrence and that the public should be informed of the proposed remedy.

It had long been clear to the author that the existing chlorination contact tank was far too small by all modern standards, but never before had there been any occurrence which justified putting forward a proposal to spend money on a larger tank. Prior to the discovery of the nematode and rotifer infestations, the author had considered the adoption of terminal superchlorination and dechlorination. The high resistance of the fully grown nematode specimens to chlorination, together with the unpleasant decomposition products of *Nais,* as well as the large

number of rotifers, made it seem desirable, however, that physical removal of the various organisms should be effected before the application of terminal chlorination.

There appeared to be no way of organizing slow sand filter treatment to prevent seasonal recurrences of the troubles. The solution to the problem lay either in the replacement of all slow sand filters by a rapid sand plant or in the installation of microstrainers between the filters and the chlorination contact tank.

The first of these alternatives would, of course, have been very expensive. In addition, it did not seem to offer a reasonable certainty of success, because there was evidence of infestations in other systems where rapid sand filters were in use.

Results obtained with the experimental microstrainer cylinder indicated that plant-scale use of this equipment would almost certainly be successful. The 23-μ aperture of the microstrainer fabric seemed to be sufficiently small to prevent the organisms from passing through. Some of the worms had a thickness smaller than 23μ, but it seemed they would have little chance of penetrating the fabric before being washed off to waste. Also, it was likely that any organisms passing through would be immature and succumb readily to chlorination.

Consequently, it was decided to install two 10-ft diameter microstrainers and a large chlorination contact tank, with provision for superchlorination and for dechlorination by sulfur dioxide after the period of contact. Upon completion of the installation, all water, including that from the rapid sand filters, is to be passed through the microstrainers and the tank.

Determination of Radioactive Strontium and Barium in Water

Richard B. Hahn and Conrad P. Straub

A contribution to the Journal by Richard B. Hahn, Assoc. Prof. of Chem., Wayne Univ., Detroit; and Conrad P. Straub, Sr. San. Engr., Robert A. Taft San. Eng. Center, US Public Health Service (assigned to Oak Ridge National Lab., Oak Ridge, Tenn.).

THE expanding use of radioisotopes in medicine and research has resulted in an increase in the amounts of radioactive materials discharged into the environment. A recent survey (*1*) showed that more than 40 per cent of the users of radioactive materials dispose of them by discharge into the sewerage system. These materials eventually find their way into watercourses, some of which may be used as sources of supply.

Present day discharge levels present no immediate health problem. The continued and expanded use of radioactive materials and their discharge into streams may, however, result in concentrations of radioactive materials exceeding the limits recommended by the National Committee on Radiation Protection (*2*). With the development of a nuclear-power industry in the foreseeable future, larger amounts of radioactive materials will be released into the environment. These discharges will have to be maintained at levels which are noninjurious to the ecology of the given area.

Radiochemical Procedures

To determine which radioisotopes are present in the water, radiochemical procedures are employed. The water works profession should be familiar with techniques for the separation and identification of at least the more critical fission products and other radioisotopes used and discharged in its watersheds. The most hazardous of all beta-emitting radioisotopes in water is strontium, Sr^{90}, in equilibrium with its daughter product yttrium, Y^{90} (*2*). Other hazardous fission product isotopes are Sr^{89}, Y^{91}, Zr^{95}, Nb^{95}, Ru^{106}-Rh^{106}, I^{131}, Cs^{137}-Ba^{137}, Ba^{140}-La^{140}, and Ce^{144}-Pr^{144}. In addition, P^{32} and Co^{60} may be of interest to the water works chemist.

As Sr^{90}-Y^{90} is the most hazardous radioisotope, methods for its determination in natural water were studied first. It is formed in relatively large amounts in nuclear fission. The parent Sr^{90} has a half-life of about 20 years, the yttrium daughter a half-life of 61 hr. Upon ingestion, the strontium is concentrated in the bone and is eliminated slowly. The maximum permissible concentration (MPC) in water for continuous ingestion (70 years) of Sr^{90}-Y^{90} is 8×10^{-7} microcuries (μc) per milliliter (*2*). It is desirable, therefore, to have an accurate analytical method for the detection and determination of this radioisotope in low concentrations in waters used for human consumption. Since radiobarium must be removed along with the radio-

strontium, it is convenient to determine any radioactive barium during the analysis for strontium. The MPC value for Ba^{140}-La^{140} is 2×10^{-3} μc per milliliter of water (*2*).

Procedures for the identification, separation, and determination of other hazardous radioisotopes listed above will be developed in the future.

Methods have been reported for the estimation of radioactive strontium in river and other waters (*3, 4*). Duncan and colleagues (*3*) precipitated the strontium and barium with sodium carbonate, treated the carbonates with 80 per cent nitric acid, dissolved the nitrates in water, reprecipitated the strontium as a carbonate with sodium carbonate, and counted the precipitate. This method, however, would not give accurate results in waters containing much calcium, as this element is partially precipitated with the strontium. Barium was separated from the strontium as a chromate from acetic acid solution. Mawson and Fischer (*4*) preferred the ammonium oxalate precipitation of strontium, but also studied the sodium carbonate and barium sulfate precipitation methods.

Excellent analytical methods have been devised for the radiochemical analysis of barium and strontium in mixtures of fission products (*5*). These methods, however, were developed for the analysis of small volumes of solutions containing relatively high concentrations of the radioisotopes. Interferences caused by other inactive elements, such as calcium and magnesium, which are present in most natural waters have been investigated in part (*3, 4*). In adapting the procedures of Glendenin (*5*) to the analysis of low-level activities in natural waters, large volumes of water must be used and the radioactive components must be concentrated to obtain accurate results; also, the interference of calcium, magnesium, iron, and other substances must be evaluated.

Experimental

In all the experiments, a tracer solution of Sr^{90}-Y^{90} or Ba^{140}-La^{140}, obtained from the Operations Div., Oak Ridge National Laboratory (ORNL) as a chloride in HCl solution, was used. These solutions were standardized by the procedure given by Glendenin (*5*). Samples were mounted on 1-in. watch glasses and were counted with a mica end-window Geiger-Muller tube having a window thickness of 2.3 mg per square centimeter. A standard of uranium oxide in equilibrium with its decay products was counted after each experiment, and fluctuations in the daily efficiency of the counter were corrected by multiplying the final count in each experiment by the proper correction factor.

Because of the long half-life of Sr^{90}, no corrections were made for decay in comparing the count in the various experiments with the count obtained in the standardization of the Sr^{90}-Y^{90} tracer solution.

Concentration Methods

Three methods of concentration were studied: evaporation, ion exchange, and precipitation. These are described in the following paragraphs.

Concentration by evaporation. Twenty milligrams of Sr^{++} (as $Sr(NO_3)_2$ solution) carrier and 100 λ of Sr^{90}-Y^{90} tracer were added to a liter of Oak Ridge tap water. (Average analyses of this water are given in Table 1.) This was evaporated to about 5 ml, transferred to centrifuge tubes, and analyzed for Sr^{90} activity by the fuming nitric acid method devel-

oped by Glendenin (*5*). Quantitative recovery of the Sr^{90} was obtained. As the time and attention required for evaporation of several liters of solution make this method impractical, concentration by evaporation was not studied further.

Concentration by ion exchange. A cation-exchange resin, Amberlite IR-120,* converted to the hydrogen form with 6*M* hydrochloric acid, was used in this experiment. A column 1.5 cm in diameter and 50 cm in height was prepared.

TABLE 1

Oak Ridge Tap Water Analyses
(Four Determinations)

Item	Amount *ppm*
Methyl orange alkalinity (as $CaCO_3$)	90–99
Phenolphthalein alkalinity (as $CaCO_3$)	0–2
Soap hardness (as $CaCO_3$)	90–108
Dissolved solids	104–142
Nonvolatile solids	72–80
Ca	23–27
Mg	5–8
Na	1–6
SiO_2	2.5–7
Nitrate	1.2–1.75
pH	7.3–7.9
Color	0
Odor	0
Dissolved CO_2	1–3
Fe	<0.03–0.04
Al	0.039–<0.05
Cu	<0.02–<0.05
Ni	<0.02–<0.05
Cr	<0.02–<0.05
U	
SO_4	9–30
Cl	3.7–7.4
CO_3	54–59.4
HCO_3	112–120
PO_4	1.6–4.6
F	<1.0–1.0

Ten liters of Oak Ridge tap water containing 20 mg of Sr^{++} carrier and Sr^{90}-Y^{90} tracer were passed through the column at a rate of approximately 2 ml per minute. The column was eluted with 300 ml of 2.5*M* hydrochloric acid, the resulting solution concentrated by evaporation, and the Sr^{90} activity determined by the procedure of Glendenin (*5*). Only 80 per cent of the added activity was recovered. In all probability this low recovery was caused by calcium contamination of the final precipitate of strontium oxalate rather than by an actual loss of activity.

Concentration by ion exchange was deemed impractical for the following reasons: [1] a period of several days is required for the absorption and elution of the activity; [2] the eluted solution must be concentrated by evaporation; and [3] interfering ions are concentrated, as well as the desired radioactive materials. Ion-exchange techniques may be useful in concentrating activities from large volumes of soft water (rain water, for example), but not with waters containing appreciable concentrations of dissolved solids.

Concentration by precipitation. Precipitation from ammoniacal solution by the addition of saturated ammonium oxalate solution and precipitation by the addition of 1*M* sodium carbonate were investigated. Both precipitants gave a granular precipitate which settled slowly. As the oxalate precipitate concentrated calcium ions in preference to strontium, this method was not investigated further.

It was found that all of the strontium activity was carried down in the carbonate precipitate, which settled out satisfactorily in 1–3 hr. Therefore, this procedure (described in detail in the Appendix, page 339) was selected for the concentration of barium and strontium activities. In concentrating the strontium (with or without bar-

* A product of Rohm & Haas Co., Philadelphia.

ium) activity by precipitation as strontium (barium) carbonate, it was found that calcium carbonate, magnesium carbonate, ferric hydroxide, and aluminum hydroxide were also precipitated. Magnesium, aluminum, and ferric ions, up to 100 mg each, did not interfere in the determination of the strontium activity. When more than 25 mg of calcium ions were present, however, this element was carried along and precipitated with strontium (barium) in the final precipitate used for counting. It was found that this impurity could be eliminated by treating the precipitate of strontium nitrate, barium nitrate, and coprecipitated calcium nitrate with anhydrous acetone. This reagent dissolved the calcium nitrate and left the strontium and barium nitrates undissolved. The nitrate precipitate was dissolved in water, fuming nitric acid added, the precipitate dissolved again in water, 5 mg Fe^{+++} in the form of $Fe(NO_3)_3$ added, and the $Fe(OH)_3$ precipitated with ammonium hydroxide. The supernatant was neutralized with nitric acid, and acetic acid and ammonium oxalate were added, followed (after heating) by the addition of sodium chromate. The supernatant liquor was used for the determination of strontium, and the precipitate for barium. Specific methods for

TABLE 2

Determination of Sr^{90} or Ba^{140} Activity in Water

Run No.	Sample and Source	Activity Added		Gross Beta Count	Activity Recovered or Found*		Recovery of Carrier	
		Sr^{90} *cpm*	Ba^{140} *cpm*	*cpm/ml*	Sr^{90} *cpm*	Ba^{140} *cpm*	Sr^{90} %	Ba^{140} %
1a	4 l Oak Ridge tap water				0		79.6	
1b					6		73.1	
2a		66			75		73.5	
2b		66			76		73.8	
3a		655			723		74.7	
3b		655			682		72.4	
4a			125			124		55.7
4b			125			128		43.7
					cpm/ml			
5a	10 ml Settling Basin water†			113	21	0.2		
5b				115	23	0.2		
6a	4 l White Oak Lake water			11	4.8	1.8×10^{-3}		
6b				10	5.2	2.6×10^{-3}		
7a	4 l Clinch River water			0	8×10^{-3}	0		
7b				0	9×10^{-3}	0		

* Corrected for carrier recovery.
† This sample was concentrated by evaporation.

the determination of strontium and barium are also included in the Appendix.

Discussion and Results

The procedure detailed in the Appendix and described briefly above was tested by adding known amounts of Sr^{90}-Y^{90} or Ba^{140}-La^{140} activity to 4 liters of Oak Ridge tap water. All samples were counted immediately after separation, the counts reported being those of the pure Sr^{90} or Ba^{140} activity. The results of this series of tests are given in Table 2.

Further analyses were made to test the procedure. For this purpose, samples of water from the Clinch River, White Oak Lake, and the ORNL Settling Basin (a waste basin) were analyzed. The results of these analyses are included in Table 2. It will be seen that the method is sensitive, inasmuch as activity levels as low as 8×10^{-8} counts per minute (cpm) per milliliter for strontium and about 1.8×10^{-2} cpm per milliliter for barium were measured. These represent levels of approximately 4×10^{-8} and 10^{-7} μc per milliliter, respectively

Summary

A procedure is given for the determination of low concentrations of radioactive strontium (to about 4×10^{-8} μc per milliliter) and barium (to about 10^{-7} μc per milliliter). The method was tested on various natural and waste waters. A precision of about 10 per cent was obtained. As the method does not distinguish between the various isotopes of strontium or barium—for example between Sr^{89} and Sr^{90}—decay and absorption analyses would be required for this information.

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APPENDIX

Procedure for Determination of Strontium and Barium Activities in Water*

1. Measure out 4 liters of clear water into a 4-liter beaker. (If the activity is more than 5 beta cpm per milliliter, smaller samples may be used. Suspended matter should be filtered off and analyzed separately.) Add 20 mg each of Ba^{++} and Sr^{++} carriers.

2. Add 50 ml of concentrated (15*M*) ammonium hydroxide; heat to boiling.

3. Add 50 ml of 1*M* sodium carbonate solution to the boiling solution. Stir, then digest at 90°–95°C for about 1 hr.

* A blank sample of water should be run, along with the active samples, to determine whether any stable strontium is present in the water.

4. Set the beakers aside and let stand until the precipitate has settled (about 1–3 hr).

5. Decant and discard the clear supernate. Transfer the precipitate to a 40-ml centrifuge tube and centrifuge. Decant the supernate.

6. Add concentrated nitric acid (15*M*) drop by drop (about 2 ml) to the precipitate until it is completely dissolved. Heat to boiling, add 1 ml of water, stir, then centrifuge. Discard any residue such as SiO_2.

7. Transfer the clear supernate to a clean tube. If the volume of the solution exceeds 5 ml, it should be evaporated to 5 ml.

8. Add 25 ml of fuming nitric acid, cool, stir, and then centrifuge. It is advisable to wear rubber gloves in using fuming nitric acid. Discard the supernate. Invert the tube in a beaker for about 10 min to drain off most of the excess nitric acid.

9. Add 25 ml of anhydrous acetone, stir thoroughly, cool, and then centrifuge. Discard the supernate.

10. Repeat Step 9 if more than 200 mg of Ca^{++} is present in the water sample.

11. Dissolve the precipitate of $Sr(NO_3)_2$ and $Ba(NO_3)_2$ in 5 ml of water, and heat to boiling for about 30 sec to remove any remaining acetone.*

12. Add 15 ml of fuming nitric acid. Cool, stir, and then centrifuge. Discard the supernate.

13. Dissolve the precipitate in 10 ml of water, add 5 mg of Fe^{+++} in the form of $Fe(NO_3)_3$ solution, and precipitate $Fe(OH)_3$ by making the solution basic with 6*M* ammonium hydroxide. Centrifuge and decant the supernate to a clean tube. Discard the $Fe(OH)_3$ precipitate.

14. Add a drop of phenolphthalein indicator; then add 6*M* nitric acid dropwise, with stirring, until the solution is neutral. Add 1 ml of 6*M* acetic acid and 2 ml of 6*M* ammonium acetate. Heat to boiling; then add 1 ml of 1.5*M* sodium chromate with stirring. Continue stirring for 1 min and then centrifuge. Decant the supernate to a clean tube and use it for the determination of strontium (Step 15). Save the precipitate for the determination of barium (Step 16).

15. *Determination of strontium.* Add 2 ml of concentrated ammonium hydroxide (15*M*) to the supernate from Step 14. Heat to boiling; then add 5 ml of saturated ammonium oxalate solution. Stir and then filter by suction on a small weighted filter paper disc in a small Hirsch funnel. Wash three times with 5-ml portions of water, three times with 5-ml portions of 95 per cent ethyl alcohol, and three times with 5-ml portions of ethyl ether. Transfer the paper and the precipitate to a watch glass; dry 5 min at 90°–100°C in an oven; then mount and count the precipitate. The final precipitate is $SrC_2O_4 \cdot H_2O$.

16. *Determination of barium.* Use the precipitate of barium chromate obtained in Step 14. Wash the precipitate with 10 ml hot water. Centrifuge, discard the supernate, and then add 2 ml of 6*M* hydrochloric acid. Heat to boiling to dissolve the precipitate, cool, and then add 15 ml of hydrochloric acid–ether mixture. (The hydrochloric acid–ether mixture is made by adding 500 ml of cold concentrated hydrochloric acid to 100 ml of ethyl ether.) Chill and stir for 1–2 min and then centrifuge. Discard the supernate.

17. Dissolve the precipitate in 1 ml of water; then add 15 ml of hydrochloric acid–ether mixture. Chill, stir, centrifuge, and discard the supernate.

18. Transfer the precipitate to a weighed filter paper disc in a Hirsch funnel with three 5-ml portions of absolute ethyl alcohol, using suction for filtration. Wash with three 5-ml portions of ether. Transfer the precipitate to a watch glass. Dry 5 min at 80°–90°C; then weigh, mount, and count. The final precipitate is $BaCl_2 \cdot H_2O$.

* The procedure from this point on is essentially the same as that given by Glendenin (*5*).

Ground Water Sources on Long Island

Joseph E. Upson

A paper presented on Sep. 9, 1954, at the New York Section Meeting, Montauk, N.Y., by Joseph E. Upson, Dist. Geologist, US Geological Survey, Mineola, N.Y. Publication authorized by the Director, US Geological Survey.

THIS article briefly describes the geologic formations that yield water to the thousands of wells on Long Island, N.Y. In 1953 the estimated gross pumpage of ground water on the island was about 260 mgd, on the average.

Figure 1 shows the island outline, the four counties on it, and the location of the generalized cross section in Fig. 2. Although Long Island is immediately adjacent to rocky New England, it is geologically more like the Atlantic Coastal Plain. The bedrock surface beneath western Long Island slopes southeastward. The unconsolidated deposits, which rest on the bedrock, extend to depths ranging from only a few tens of feet below sea level in northwestern Queens County to 2,000 ft or more beneath the south shore of Suffolk County. In central Suffolk County, test wells encountered bedrock at more than 1,400 ft below sea level (1,500 ft below land surface). These deposits make a huge ground water reservoir.

Unfortunately, the island is surrounded by salt water, a fact that must be taken into consideration in using the fresh water. Other complications are introduced by the variations in the lithologic—and, hence, the water-bearing—characteristics of different layers of the unconsolidated deposits. Some layers are much less permeable than others and yield essentially no water, but this fact has its good as well as its bad side.

Upper Pleistocene Deposits

The top layers comprise relatively coarse-grained deposits that consist of several subunits, hard to distinguish geologically, and of different origin, but all laid down in the latter part of the Pleistocene or glacial epoch. Therefore, they are called "Upper Pleistocene" deposits. They underlie practically all of Long Island and attain a maximum thickness of 200–300 ft.

They can be divided into three main categories: [1] morainal deposits, which form two subparallel, longitudinal ridges extending almost the full length of the island; [2] stratified deposits which form the outwash plain south of the southern of the two moraines in most of the island; and [3] a complex sequence of deposits between the two moraines and north of the northern one.

The northern, or Harbor Hill, moraine extends from Kings County out along the north fork; the southern, the Ronkonkoma Moraine, extends from western Nassau County out along the south fork. In the western part of the island, these deposits are composed

largely of clay and gravel, in which water is locally perched on the more clayey portions. In the eastern part of the island, these deposits are chiefly sand and gravel and seem to permit ready downward percolation of water at most places.

The stratified deposits south of the Ronkonkoma Moraine consist mainly of sand and gravel, but near the shore they have intercalated lenses of marine clay and some alluvium, which are not differentiated on most small-scale maps. These deposits are 100 ft or more in thickness and, nearly everywhere, yield water readily to wells.

The complex sequence in the northern part of the island occurs between the two moraines and on the peninsulas of the north shore, mainly in Queens and Nassau counties. The deposits consist mostly of stratified sand and gravel, at least partly glacial outwash. They also have two units of clayey till, one in the midst of the sequence and the other at the land surface. The extent and continuity of all these deposits, the details of their origin, and their interrelationship are complex and not fully understood. These deposits comprise several geologic formations recognized by earlier writers, but not currently distinguished.

Except for the parts of the morainal areas that are underlain by clayey till, and other areas underlain by clay, the Upper Pleistocene deposits can absorb water and readily transmit it downward to the water table, which ranges from 50–60 ft below the land surface to only about 1 ft. The water table is shallowest near the shores. In the clayey-till areas, some local bodies of water are perched above the main water table.

The Upper Pleistocene deposits receive essentially all their recharge from rain and snow. Some of this is transmitted downward to the underlying formation, while some is transmitted

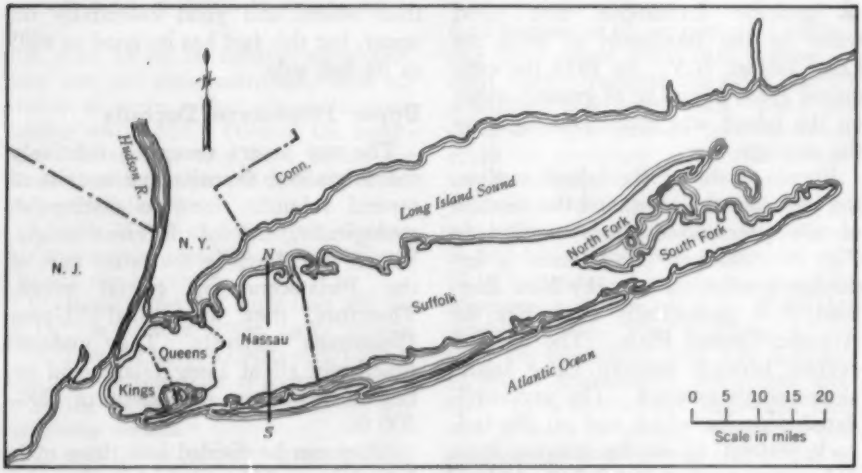

Fig. 1. Map of Long Island

Line N–S indicates location of cross section in Fig. 2.

only through the Upper Pleistocene deposits and discharged directly into the atmosphere or into the ocean and bays or the streams that flow to them. Actually, most of the stream flow of Long Island is sustained by ground water discharge. At places near the shore, the Upper Pleistocene deposits may receive some water coming up from underlying formations—water that originally percolated downward in the central part of the island.

Because of their permeability, thickness, and widespread occurrence, the Upper Pleistocene deposits are the most productive geologic unit. In 1953 they yielded about 50 per cent of the gross pumpage on Long Island. Throughout much of the extent of these deposits, cesspool wastes and other possibly contaminated waters from the surface can readily percolate downward. Hence, there is a tendency to develop more water from deeper aquifers. Little is known about the occurrence of water in the Upper Pleistocene deposits of the northern part of the island.

Jameco Gravel

The Jameco gravel is the next aquifer stratigraphically below the Upper Pleistocene deposits. It is a body of highly permeable sand and gravel whose extent is limited to Kings County, the southern part of Queens, and the southwestern part of Nassau. This deposit is not known in Suffolk County. The Jameco, which is thought to have been deposited by melt water streams from glaciers of pre-Wisconsin age, seems to fill, and in part extend beyond, a system of valleys cut in the underlying deposits.

The Jameco gravel ranges in thickness from less than 1 ft to as much as 150 ft and lies everywhere 80 ft or more below sea level. It consists mainly of coarse sand and gravel but has some scattered lenses of silt and clay. The formation was once a source of considerable water in Kings County. After several years of relatively heavy pumping, water of high chloride concentration was drawn in, causing abandonment of all public supply wells in

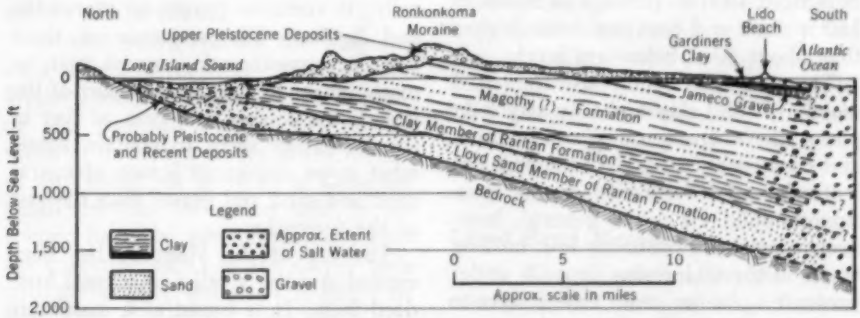

Fig. 2. Water-bearing Formations in Central Long Island

A section of Nassau County is shown. There are seven formations, only four of which readily yield water. The Gardiners clay and Raritan clay strata create artesian pressure and help keep sea water out.

that county (*1*). The Jameco still yields substantial quantities of water in Queens County and in southwestern Nassau. Although of limited extent, it yielded about 5 per cent of the gross pumpage in 1953.

Throughout essentially all its extent, the Jameco gravel is overlain and separated from the Upper Pleistocene deposits by Gardiners clay. This fossiliferous interglacial marine deposit occurs in nearly all of Kings County, the southern half of Queens County, part of southwestern Nassau County, and small sections of Suffolk County. It is from 10 ft to perhaps as much as 150 ft thick and does not occur higher than about 50 ft below sea level.

The Gardiners clay is composed mostly of solid clay and silty clay. At places there are some silt, fine sand, and even coarse sand. As the beds are lenticular, the formation is not continuous solid clay. In general, however, it acts as a confining bed, holding water in the underlying deposits under pressure. At the same time it acts to some degree as a barrier to the movement of ocean water. At places where interconnecting lenses of sand make up much of the formation, it can, of course, transmit water more readily than elsewhere. By way of such permeable channels (and probably also by very slow movement even through the clays) water can pass through the formation where the hydraulic gradient is favorable. This replenishes the underlying Jameco gravel, although much of the replenishment for that unit may come from the underlying Magothy * formation.

* The designation "Magothy" is used with reservations, as the correlation of these deposits with similar ones in New Jersey, to which the name was first applied, is questionable.

Magothy Formation

The Magothy formation is a thick body of Cretaceous age continental deposits that underlies the Jameco gravel or younger formations, where the Jameco is absent. The Magothy underlies the southeastern third of Kings County, the southeastern two-thirds of Queens County, essentially all of Nassau County, and, as far as known, all of Suffolk County.

The formation consists of a complex alternation of lenses of silty clay, silt, and fine and coarse sand; some lenses of solid clay; and some of gravel. Locally, it contains pyrite or marcasite, and lignite. The sequence of these beds is unsystematic, except that, at many places in the western part of the island, the lowest few tens of feet of the formation seem to contain somewhat more numerous lenses of coarse sand and sand and gravel than the rest of the formation.

The top of the Magothy has been eroded and has a relief of several hundred feet. It is found at a maximum height of about 220 ft above sea level in east-central Nassau County and is as deep as 350 ft below sea level in southern Queens. It may be at comparable depths in south-central Suffolk County. The bottom of the formation is much more uniform than the top, conforming somewhat to the configuration of the deeper bedrock surface. Thus, the thickness ranges from a featheredge in Kings County to several hundred feet beneath the north shore of Suffolk County, and substantially more beneath the south shore. In southwestern Nassau County, this formation is 400–500 ft thick, and, in southern Suffolk County, at least 700 ft thick.

In Kings, Queens, and Nassau, the Magothy is overlain mostly by the Up-

per Pleistocene deposits, except in the southern parts of those counties, where it is directly overlain at most places by the Jameco gravel and at some localities by Gardiners clay extending beyond the Jameco. Where the Magothy is directly overlain by the Jameco, the water in the two formations is in hydraulic continuity.

Along the south shore of eastern Nassau County and Suffolk County, the Gardiners clay intervenes between the Magothy and the Upper Pleistocene deposits. In central Suffolk, the Gardiners extends north as far as the middle of the island.

Ground water reaches the Magothy only after percolating through the Upper Pleistocene deposits. It is more or less confined everywhere, not so much in the upper layers in the middle of the island, but more so in those beneath the Gardiners clay and in the deeper parts of the formation where the confining effect of the clayey beds within the Magothy itself is felt. At most places along and near the southern shores of the island, wells in the Magothy have a natural flow. The head is 4–5 ft above sea level in southwestern Nassau County and 8–9 ft above sea level at Merrick, within a few miles of the Suffolk County line. Farther east along the shore, the head increases.

It is not known to what extent the fresh water in the formation is in hydraulic continuity with the present ocean water south of the island. The lower part of the Magothy at Atlantic Beach, near the west end of the south shore barrier beach, contains water with more than 1,600 ppm chloride. Farther east the water is fresh. Thus, to the east, the pressure head of the fresh water is enough to hold back the salt water.

Along the north shore of the island, the Magothy crops out at a few places and doubtless extends some distance north of the shore beneath the sound. Younger deposits probably intervene between the Magothy and the ocean water, but their nature is unknown. Some ground water is pumped from the Magothy in north shore areas, but little is known about the opportunity for or danger of sea water encroachment in those areas.

The Magothy is the largest aquifer of Long Island, although in 1953 it produced only about 35 per cent of the gross pumpage. It is deep beneath most of the island and is relatively fine grained, making well development difficult. Also, although present heads in most places are high, the formation seems to be open to potential sea water encroachment along both the north and south shores.

Lloyd Sand Member

The Lloyd sand aquifer, the lower member of the Cretaceous age Raritan formation on Long Island, is the deepest of the aquifers. It does not crop out, but it underlies essentially all the island and extends unknown distances northward beneath Long Island Sound and southward beneath the Atlantic.

The Lloyd sand member consists mostly of sand and fine gravel and some lenses of clay, sandy clay, and fine sand. The lenses of sand and gravel seem to occur prominently in two or three fairly distinct zones, separated by less permeable zones consisting of clay and silt. There is some evidence that the water-yielding zones in the Lloyd are somewhat more permeable in the western part of the island than in the eastern part.

The top of the Lloyd may have been somewhat eroded in the northern parts of Kings and Queens Counties during

some time after it was laid down, but elsewhere it apparently was not. The Lloyd slopes southeastward more or less parallel to the underlying bedrock surface. The top ranges from about 100 ft below sea level in northern Queens and Nassau to 1,400 ft below sea level in southeastern Nassau and perhaps as much as 1,700 ft below in Suffolk County. The thickness increases slightly southeastward but in most places is about 250 ft.

The Lloyd sand member is almost universally overlain by the clay member of the Raritan formation, locally known as the "Raritan clay." This member, of continental origin, consists mainly of silty and solid clays and some lenses of sand and silty sand. Some of the clay beds contain lignite and pyrite, as well as leaves, plant spores, and partly carbonized wood. Because the member is chiefly of clay, much of it compact and solid, it forms an effective confining layer beneath which the water in the Lloyd sand member is held under artesian pressure. In the central parts of the island, the hydraulic gradient is downward from younger formations to the Lloyd. Thus, recharge can take place either by slow and devious percolation through and around the lenses of clay or silt, or possibly through erosional gaps in the clay member, as postulated by some geologists (*2*).

Near the shores of the island, the hydraulic gradient is upward from the Lloyd sand member to the overlying deposits. Accordingly, some Lloyd wells drilled close to sea level obtain flowing water. The artesian pressure also evidently holds back salt water so that, for example, wells near the western end of the barrier beach that pass through salt water in the lower part of the Magothy obtain fresh water in the underlying Lloyd. At one or two places along the north shore of Suffolk County, however, wells drilled into the Lloyd in early years reportedly encountered salty water.

The Lloyd sand member is at present a little tapped aquifer (yielding only about 10 per cent of the 1953 gross pumpage) and could presumably sustain additional development. It has the advantage of supplying fresh water in areas where salty water occurs or may occur at shallower depths. Also, it is relatively permeable. But, beneath the south shore, it is deep and expensive to develop, and receives as replenishment only water that has already percolated through the overlying aquifers. Along the north shore it may have a nearby hydraulic connection with sea water. Because of these factors the Lloyd may not be susceptible to extensive development.

Summary and Conclusions

There is a large volume of fresh water beneath Long Island. At most places, wells can be, and are, constructed to yield hundreds of gallons per minute. A number of the aquifers (to some extent and at some places) are "protected" by relatively impermeable strata from encroachment by the sea. Despite appearances, the supply is not unlimited. Withdrawals for public supply in Kings were stopped in 1947 because of salinity. Water levels in one or two Queens wells show a decline. The net withdrawals from ground water in Nassau County, on the order of 50 mgd in 1953, are a substantial fraction of the estimated total water available now. If population and water use continue to increase, the net withdrawals may approach the available supply in the foreseeable future. Should present trends continue,

the ultimate critical question will be how much fresh water can be pumped, and from what sources, without causing serious encroachment by sea water.

It has been shown that much—but far from all—of the general background needed for understanding the source and occurrence of ground water in Long Island (especially the western part) is known. For much of Suffolk County, even the general background is not well known. But more important at present, in the western part of the island, where heavy and increasing withdrawals are concentrated in small areas, the general background is no longer good enough. Adequate knowledge of the details and smaller-scale features that control or reveal the occurrence and movement of the ground water is not available.

For example, in northwestern Nassau County and adjoining parts of Queens, water of relatively high chloride concentration has been observed in a few wells. To cope with this problem adequately, the direction from which this salty water came and the conditions under which it has moved in the past and may move in the future must be worked out. Also, in any estimation of the total water available in the north shore peninsulas of Nassau County, bordered by salt water on three sides, it would be necessary to have such information as the extent to which rain falling on the land surface in those areas may be intercepted by impermeable strata at shallow depth and diverted before reaching the deeper aquifers that now supply most of the water. Furthermore, one significant element of the total discharge of water from Long Island is thus far essentially unmeasured: the amount of water in drains and storm sewers that is conducted directly or indirectly to the sea, correspondingly reducing the natural replenishment.

Thus, there are still large gaps in the knowledge of the geology and hydrology of Long Island. As water use increases, so will the importance of filling these gaps.

Acknowledgments

Descriptions of the various water-bearing formations of Long Island are based largely upon a report made by the author's colleagues, Wallace de-Laguna and N. M. Perlmutter (*3*). These data are supplemented by others collected since 1949, particularly the results of test drilling in southwestern Nassau County to investigate sea water encroachment. A report on that study is in preparation. All the information on which this paper was based has been obtained in the course of long continued investigations of Long Island ground water resources, financed jointly by the US Geological Survey, the Nassau County Dept. of Public Works, the Suffolk County Board of Supervisors, the Suffolk County Water Authority, and the New York State Water Power and Control Commission.

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Conservation of Ground Water on Long Island

Arthur H. Johnson

A paper presented on Sep. 9, 1954, at the New York Section Meeting, Montauk, N.Y., by Arthur H. Johnson, Assoc. Engr., State Water Power & Control Com., Jamaica, N.Y.

LONG ISLAND, which is a part of New York State, has a land area of approximately 1,373 sq miles and is situated in the Atlantic Ocean northeast of New York City. The island, about 120 miles in length and a maximum of 23 miles in width, is separated from the mainland by Long Island Sound, a body of salt water 1–15 miles wide (see map, page 342). The topography of the island is quite uneven, with the southerly half composed of low, flat plains, except at the extreme eastern end. The northern shore of the island consists of rolling hills indented by numerous bays and harbors.

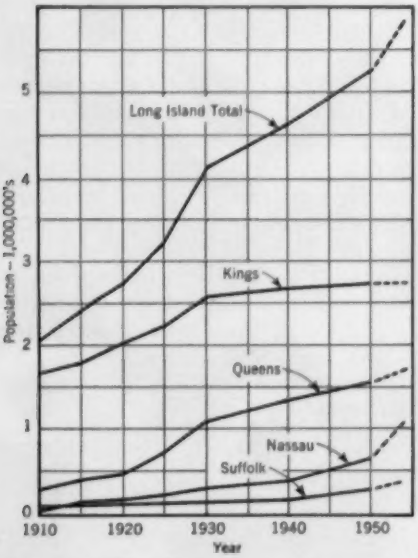

Fig. 1. Long Island Population Growth

The solid lines are based on census figures; the broken lines represent estimates.

According to the most recent estimates, more than 5,000,000 persons reside on Long Island, about two-thirds of them in the western third of the island, in the counties of Kings (Brooklyn) and Queens (Fig. 1). During the past 5 years there has been an above-average increase in the development of large real estate subdivisions, especially in Nassau County, where many large truck farms have been acquired for residential housing projects. Levittown, in Nassau County, with more than 10,000 homes and a population of approximately 52,000, is an example of the tremendous growth in that county. With most of the available land in Nassau County subdivided, developers are presently extending their operations into Suffolk County, which is the largest of the four Long Island counties in area but the smallest in population.

Prior to 1917 all fresh water used for domestic and industrial purposes was obtained from surface streams, ponds, and wells. The available supply up to that time met all water requirements. According to records of the US Weather Bureau, the average annual precipitation on Long Island over a 50-year period was about 42 in.

Water level measurements, as recorded at numerous county and private observation wells throughout the island, fluctuated with the rate of precipitation. industrial plants were constructed in Kings and Queens counties, requiring large amounts of water. Immediately after World War I many large-capacity

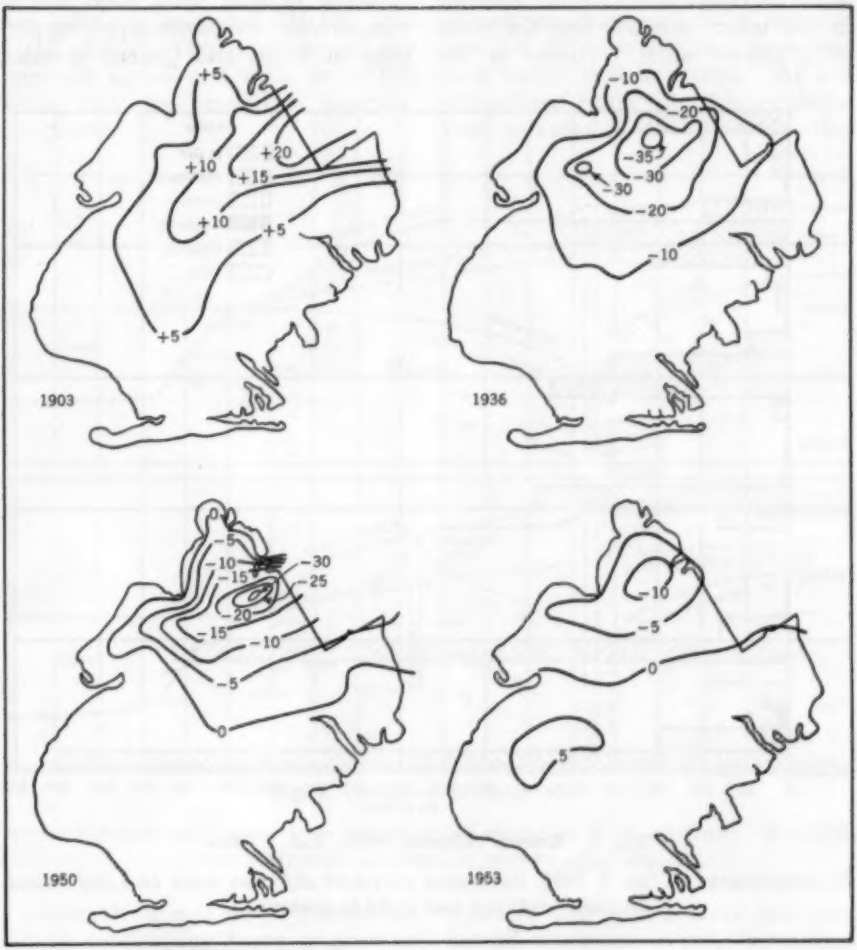

Fig. 2. Kings County Ground Water Elevations

The evident improvement since 1950 is also indicated in Fig. 5 (page 353).

Up to about 1917 there was little concern about the large amount of fresh water withdrawn in certain areas and wasted to the sea after use. During World War I, however, many large wells were put down; at first these were relatively shallow and were operated by suction lift. After several years of heavy pumping, the lowering of water levels in Kings and Queens

led to the introduction of the deep well turbine pump. Continued drilling without control, together with heavy pumping in the industrialized areas of Kings and Queens, resulted in salt water intrusion into the wells of a private water company in the 2 shows the trend in Kings County water levels since 1903.

Early in 1930 the serious water situation in western Long Island made it apparent to New York City, and to various water companies supplying portions of Kings and Queens counties,

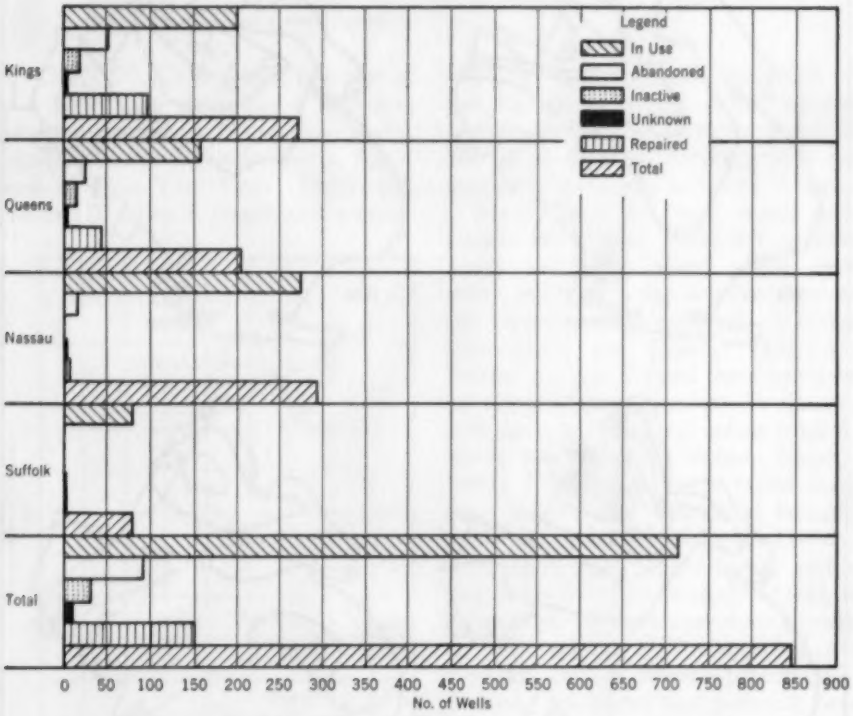

Fig. 3. Known Diffusion Wells, Jan. 1, 1954

By comparison, on Jan. 1, 1935, there were only nine diffusion wells on Long Island, one in Kings and eight in Queens.

Flatbush section of Kings. Later many complaints about the quality of this water by residents culminated in condemnation proceedings by New York City, and, on Jun. 30, 1947, all wells supplying water to the Flatbush franchise area of the New York Water Service Corp. were shut down. Figure

that the control of industrial pumping was essential. In 1931 the New York State legislature set up a joint committee to investigate the potable-water resources of the state. In April 1933 the legislature placed the ground water resources of Long Island under the jurisdiction of the New York State

Water Power and Control Commission. This act required commission approval for the drilling of any new well or wells when the total capacity (old and new wells) on, or for use at, one property exceeded 100,000 gpd (69.4 gpm).* This provision did not apply to agricultural wells or to fire wells with no permanent pumping equipment.

The commission has usually required that water pumped from new cooling and air-conditioning wells must be returned to the same aquifer in an uncontaminated condition, through an approved structure such as a diffusion well. A diffusion well may be defined as a supply well in reverse. At first the drillers' reaction to this regulation was unfavorable, but gradually they

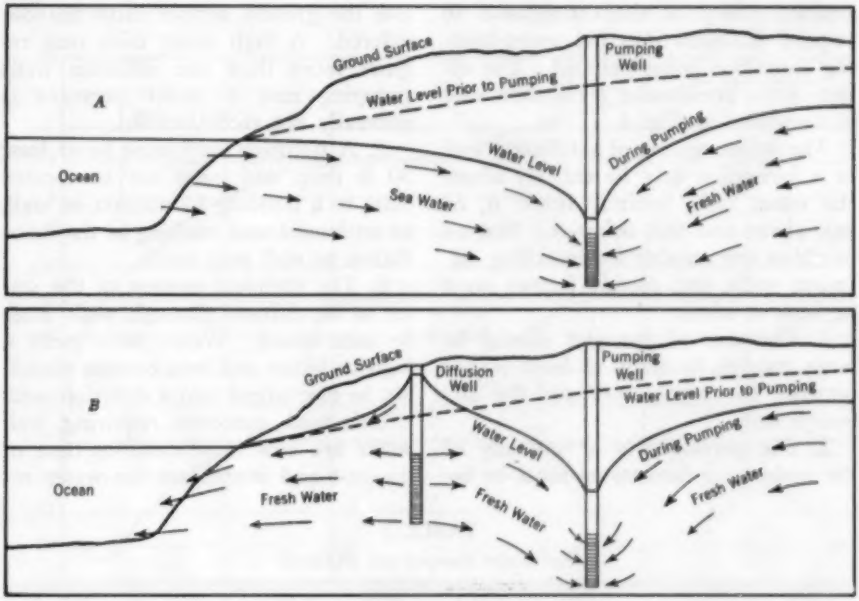

Fig. 4. Effect of Diffusion Well

A—*no diffusion well; water from pumping well wasted to ocean after use.* B—*diffusion well; water returned to ground after use.*

About the time of the passage of this act air conditioning began to grow in popularity. By 1938 more than 100 wells for cooling or air-conditioning purposes had been completed. By the end of 1953 this figure had risen to 358, an average of about 25 a year having been completed since 1949.

conceded that putting down two wells instead of one was to their best advantage. From 1933 through 1953, 849 diffusion wells were sunk on Long Island, approximately 715 of which were still in use as of Jan. 1, 1954 (Fig. 3). Records compiled by the Water Power and Control Commission indicate that during 1953 approximately 40 mgd of well water was

* Reduced to 45 gpm by an amendment passed in 1954.

pumped and returned to the ground through diffusion wells or other structures (Table 1).

The first diffusion wells constructed in 1934 had steel casings, with slots ¼ in. wide and 3 in. long burned into the lowermost casing, which took the place of a standard well screen. At present well screens made of a copper-silicon alloy or other approved materials are generally specified. It is a general policy of the commission to require diffusion into the water-bearing formation being pumped. The effect of the presence of a diffusion well is illustrated in Fig. 4.

The screen setting of a diffusion well in a formation may be entirely above the water table, entirely below it, or half above and half below it. Not all localities are suitable for installing diffusion wells, and certain factors must be kept in mind:

1. The size of the plot should be large enough to allow at least 100 ft between the supply well and the diffusion well.

2. The permeability or porosity of the underlying formations must be favorable for percolation. Formations with a large percentage of clay are not adapted to the return of water through diffusion wells.

3. The diffusion well must be located downstream (with reference to the direction of underground flow) from the supply well, or the temperature of the water in the latter will be increased considerably.

4. The depth of the water table below the ground surface must be considered. A high water table may require more than one diffusion well; pumping into it under pressure is generally not recommended.

5. A diffusion well must be at least 50 ft deep and must not be located close to a building foundation or wall, or settlement and cracking of the foundation or wall may result.

6. The chemical content of the water to be diffused through wells must be ascertained. Waste water with a high turbidity and iron content should not be discharged into a diffusion well.

Industrial concerns requiring well water are now more cautious than in the past and investigate the water re-

TABLE 1

*Well Water Pumped and Diffused**

Year	Kings		Queens		Nassau		Suffolk		Total	
	Pumped *mgd*	Diffused *mgd*	Pumped *mgd*	Diffused *mgd*	Pumped *mgd*	Diffused *mgd*	Pumped *mgd*	Diffused *mgd*	Pumped *mgd*	Diffused *mgd*
1936	63.2	3.7	69.8	1.0	61.2	0.7			194.2	5.4
1944	59.7	7.9	58.0	5.2	64.2	5.9			181.9	19.0
1945	52.1	7.5	52.9	4.4	49.1	6.0			154.1	17.9
1946	53.2	7.8	54.8	4.3	59.8	6.3			167.8	18.4
1947	38.8	7.7	61.5	5.2	72.8	8.7			173.1	21.6
1948	21.7	7.1	56.8	5.0	71.5	5.4	35.5	8.5	185.5	26.0
1949	21.1	9.9	62.0	4.9	91.4	5.5	38.1	7.0	212.6	27.5
1950	19.7	8.7	60.3	5.2	85.2	6.1	29.4	7.3	194.6	27.3
1951	16.1	11.8	47.1	6.0	74.8	6.7	27.5	8.4	165.5	32.9
1952	12.3	12.8	49.5	6.8	81.2	8.8	31.1	10.5	174.1	38.9
1953	12.0	12.8	52.6	4.1	101.5	11.5	33.4	12.0	199.5	40.4

* Based on full year, although much is seasonal (air conditioning). Pumpage includes public and industrial supply only.

sources of a particular area before making definite plans for new plant construction or expansion.

Diffusion well capacities vary from 100 to more than 550 gpm. There are, however, four diffusion wells in Nassau county which have each been diffusing water for the past 8 years at a rate of 900 gpm. The majority of diffusion wells have capacities of about 250 gpm (Table 2).

are thirteen county- or state-owned open basins, with an estimated capacity of 40 mil gal.

Temperature rise is one phase of the recharge of waste water through diffusion wells that must not be overlooked. In congested areas, where there are continuous lines of closely spaced supply and diffusion wells, the temperature of the water in the supply well is much higher than in less popu-

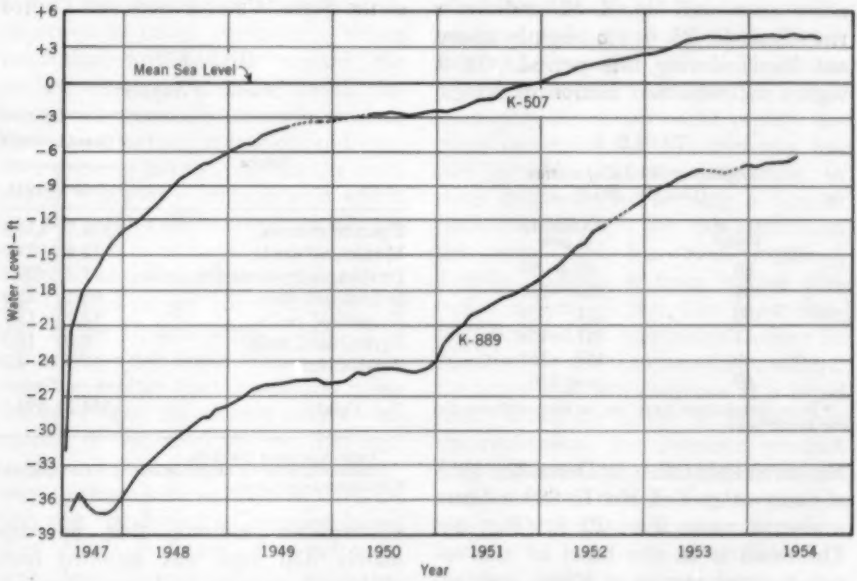

Fig. 5. Recovery of Ground Water Levels

Readings at these Kings observation wells indicate the extent of recovery since 1947.

As part of this program, Nassau and Suffolk counties are constructing a number of large, open basins to receive both storm water drainage and well water discharge. As of Dec. 31, 1951, Nassau County had 78 known open basins, with an estimated capacity of 390 mil gal. By September 1954 more than 300 such basins were in operation. In Suffolk County, there

lous sections. Records of temperatures in certain supply wells used in connection with air-conditioning systems throughout Kings County generally show an annual temperature rise of about 1.25°F over a period of years. This increase is undoubtedly due to the fact that warm waste water discharged into the ground through diffusion wells during the summer months

has not had time to cool to the temperature originally found in the supply well.

In Kings County, since June 1947, there has been a favorable balance between replenishment by precipitation and withdrawal by pumping. Ground water levels have improved greatly since the shutdown of pumping at the wells of the New York Water Service Corp. in Flatbush. Water level measurements taken in December 1953 at observation well No. K–507 indicate a rise of about 25 ft (to slightly above sea level) during this period. In a highly industrialized section of Kings, measurements taken in December 1953 at observation well No. K–889 indicate a rise of more than 29 ft (Fig. 5). This well is in the heart of the so-called crater section of Kings and, according to measurements taken in June 1954, is still 6.93 ft below sea level. The rise in water levels in the area surrounding this well can, no doubt, be attributed to the construction of many diffusion wells (some of which were put down to avoid New York City sewer rental charges) and also to the fact that many large factories, such as breweries and ice plants, either have shut down or have installed equipment to recirculate water used in cooling operations. In Queens County, however, the trend of water levels in most populated areas appears to be downward, indicating some overdevelopment.

TABLE 2

Diffusion Well Capacities
(Dec. 31, 1952)

No. of Wells*	Capacity *gpm*
89	69.4– 99
194	100 –250
100	251 –350
71	351 –450
49	451 –550
69	over 550

* Some installations have two or more diffusers for one supply well.

At present more water than ever is being supplied to Kings and Queens counties from sources outside of Long Island. Water from such a source (New York City's Catskill project) was first introduced into Long Island in 1917. Data compiled by engineers of the State Water Power and Control Commission indicate that approximately 330 mgd was supplied from off-island sources to Long Island in 1950. In 1953 the quantity thus supplied was increased to 433.5 mgd, 62 per cent of the total amount of water consumed on all of Long Island (Table 3).

TABLE 3

Sources of Supply

Source	Quantity—*mgd*	
	1950	1953
Upstate sources	338.7	433.5
Municipal* wells	72.8	74.9
Private water company wells	71.2	79.8
Industrial† wells	64.1	71.4
Household wells	13.7	13.7
Agricultural wells	6.5	16.3
Pond water	17.7	4.9
Total	584.7	694.5

* Including water districts.
† Including wells for air conditioning, sprinkling, and miscellaneous purposes.

With the current rate of increase in population and in water demand, for both domestic and industrial uses, conservation and strict control of the underground resources of Long Island are a necessity.

Elements of Corrosion Control

C. L. Crockett

A contribution to the Journal by C. L. Crockett, Chief Chemist, Motive Power Dept., Norfolk & Western Ry. Co., Roanoke, Va.

DESTRUCTION of a metal by either chemical or electrochemical action is called corrosion. When mechanical forces work toward the gradual destruction of a metal, the process is generally termed erosion. These two factors, corrosion and erosion, working jointly, produce the most serious and costly damage with which man must contend wherever metals are used.

This damage has been estimated to run as high as six billion dollars per year in the United States alone. The author does not know if this estimate includes replacement costs of items that have been depreciated over a reasonable or expected service life, but, in any event, the figure is sufficiently large to cause serious concern from an economic standpoint. Corrosion losses to a single industry, the railroads, have been conservatively estimated at $268,000,000 annually, while expenditures for protective coatings for structural maintenance are estimated to be slightly higher than $20,000,000 annually. This is less than 8 per cent of the amount chargeable against the total repair outlay for restoring losses due to corrosion. In all industries, the cost of protective coatings is normally 1–2 per cent of the total cost of new construction using steel. These figures should be a spur to action in corrosion control and prevention.

Corrosion is a natural process by which most metals tend to revert to the ore from which they come, through contact with air, water, and soil. If this reversion were to continue at a constant rate, the metal would rapidly become unserviceable. Fortunately nature provides its own protection, in some instances, by forming a film of corrosion products on the surface of the metal that has been attacked, thereby isolating it from further corrosive action. If this film is continually removed by mechanical means or dissolved in the surrounding medium, the metal loss will continue at a rapid rate. When the nature of the attack is electrochemical, the corrosion product is precipitated at a distance from the metal surface, thus failing to provide any protection from further corrosion. Actually, it is possible to consider any chemical action as electrochemical, because it is accompanied by the transfer or displacement of electrons. Usually, however, the term "electrochemical attack" is applied only when the cathodic and anodic areas are separated so that electric currents flow for perceptible distances through the metal. If this flow of current is stopped, corrosion cannot occur, and this, of course, is the main principle of corrosion prevention and control.

The types of corrosion encountered in various fields include:

1. Cathodic corrosion—resulting from a cathodic condition of the structure, usually caused by the reaction of alkaline products of electrolysis with an amphoteric metal.

2. Contact or crevice corrosion—taking place at an area where contact is made with a material, usually nonmetallic.

3. Fretting corrosion—occurring at the interface between two surfaces in contact and accelerated by relative vibration between them with an amplitude high enough to produce slip.

4. Galvanic corrosion—associated with the current of a galvanic cell made up of dissimilar electrodes.

5. Impingement corrosion—associated with turbulent flow of a liquid. For some metals, the action is accelerated by entrained bubbles in the liquid.

6. Intergranular (intercrystalline) corrosion—preferential corrosion at the grain boundaries of a metal or alloy.

7. Stray-current corrosion—caused by current passing through paths other than the intended circuit or by extraneous current in the earth.

8. Stress corrosion—corrosion accelerated by stress.

9. Rust—the most common form of corrosion.

This is by no means a complete list of the known types of corrosion, but it gives a good idea of the complexity of the problem facing the corrosion engineer. There is no single solution. Each case must be considered individually and in relation to its particular environment.

Corrosion Control Methods

Research on the prevention and control of corrosion has been intensified in recent years. Among the many materials now available are improved paints and other types of protective coatings, corrosion-resistant metals, and corrosion inhibitors. These materials, as well as cathodic protection, can do much to reduce the terrific annual corrosion loss, but they must be properly used or they will be of little benefit. Many highly rated materials have given disappointing results in service because they were incorrectly employed or were not suitable for the specific application to which they were put. It would be impossible to predict accurately the service life of a coating from laboratory evaluation, as there are so many varied conditions under which it would be used in actual practice.

The selection of the best available material for a given condition and the proper supervision of its application are the two most important factors in the prevention of corrosion. Glowing reports of the merits of a new coating do not justify its use without further investigation. There are many considerations in choosing the appropriate type of corrosion protection. Among them are: the kind of service, including the environment and local conditions; the length of service desired; the method of application, including surface preparation; the labor costs involved; appearance; compatibility; and economics.

One possible solution is the use of corrosion-resistant alloys, but these are often too costly or otherwise unsuitable. Metal plating, corrosion inhibitors, and cathodic protection are further alternatives. In some instances, several preventive measures may be necessary, such as a combination of a protective coating with cathodic protection or with an alloy.

If a protective coating is selected as the best available means for a particu-

lar environment, the manner of application, with special emphasis on surface preparation, becomes the most important factor. The final assembly or adhesion of a protective coating and a metal is determined by the molecular attraction between the coating and the metal, as well as the mechanical bonding. Because the former depends on the formulation of the coating, the latter is more subject to control by the user; he must decide how much mechanical bonding is necessary and how he can most economically obtain it. Some of the methods available for surface preparation are sand blasting, shot blasting, wire brushing, solvent or steam cleaning, and acid treating. The final step, of course, is the careful application of the coating according to the manufacturer's recommendations.

Railway Experience

The Norfolk and Western Railway has encountered a variety of corrosion problems and has attempted to solve them by all of the means previously mentioned, including: alloys, such as "Cor-Ten," produced by the United States Steel Corp.; plating with nickel, chrome, cadmium, silver, and other metals; inhibitors; cathodic protection; and, of course, protective coatings, such as alkyd resins, vinyls, vinyl plastics, epon resins, graphite paints, polyesters, asphalts, and neoprene.

Boiler corrosion, whether in locomotives or in stationary installations, is a common problem. The large majority of boilers and steam pipes are constructed of plain carbon or low-alloy iron and steel. The corrosive medium is always water, both liquid and vapor, and its behavior is influenced by its purity and the dissolved gases it contains. One of the greatest promoters of pitting corrosion is dissolved oxygen. At all temperatures and even in an alkaline solution, it is an active depolarizer. This action can usually be overcome by mechanical deaeration and the use of scavenging chemicals like sulfite.

The Norfolk and Western Railway has under test a steam turbine electric locomotive with a specially designed water tube boiler. As this is a radical departure from the conventional type of fine-tube boiler used in steam locomotives, extraordinary measures were necessary to control scale and corrosion. This boiler operates at 650-psi pressure and at temperatures up to 900°F, in the superheater units. The tubes are susceptible to pitting corrosion from dissolved oxygen, owing to the increased temperature and pressure, and control of scale is much more critical in a water tube boiler than in the conventional type.

To overcome these problems, it was first necessary to install a cation-exchange softener on the water tender behind the locomotive. Water treated in lime-soda plants is taken into the tender. This water has an average hardness of 25 ppm. As the water is required, it is pumped through the softener and the hardness is reduced to less than 1 ppm, or, for all practical purposes, to zero. The water then passes through a de-aerating heater and is mechanically atomized into an atmosphere of steam. Nearly complete removal of gases is obtained. As further insurance of the absence of hardness compounds and residual oxygen, two chemical tanks are installed on the locomotive, one containing phosphate for hardness removal, and the other sulfite for the removal of oxygen.

These chemicals are injected into the boiler feedwater by air-operated pumps whose strokes are automatically controlled by the rate of flow of the water to the boiler. An attempt is made to maintain an excess of at least 25 ppm phosphate and 30–40 ppm sulfite. The pH is kept between 10.8 and 12.0 and is regulated, along with the dissolved solids, by a continuous blowdown setting through meter controls. The railroad has operated this locomotive since May 1954, and the results of the monthly boiler inspections have been very satisfactory.

Until the tremendous annual cost of corrosion is greatly reduced, efforts to stimulate research and production of improved protective coatings and other corrosion preventives must be continued. Industry must also increase its knowledge of the corrosion problems confronting it and of the means of combating them most effectively.

Sheboygan, Wis., Dental Survey Results

Sheboygan, Wis., water has been fluoridated (1 ppm) since Feb. 25, 1946. Dental surveys of kindergarten and public school children are made in October of each year. Below are shown the results of such surveys since 1945, the year before fluoridation was begun.

Year	Kindergarten (Deciduous Teeth)				Grades 7–9 (Permanent Teeth)			
	No. of Children Examined	Per Cent With No Caries	DMF*		No. of Children Examined	Per Cent With No Caries	DMF*	
			Avg per Child	Per Cent Improvement			Avg per Child	Per Cent Improvement
1945	416	20.4	4.80	†	1,877	2.77	8.54	†
1946	520	26.9	4.32	10.0	1,590	2.61	8.09	5.28
1947	521	29.17	4.09	14.8	1,642	3.28	7.27	14.8
1948	525	32.4	3.46	27.9	1,442	3.4	6.92	19.0
1949	386	37.3	2.90	39.6	1,566	2.9	7.00	18.0
1950	404	43.2	2.58	46.2	1,522	4.2	6.67	21.9
1951	456	47.8	2.22	53.7	1,519	3.4	6.54	23.4
1952	668	51.9	1.99	58.5	1,497	4.6	6.00	29.7
1953	524	55.7	1.78	62.9	1,494	5.75	5.53	37.1
1954	549	57.6	1.68	65.0	1,486	7.8	5.06	40.7

* Decayed, missing (due to decay), and filled teeth.
† Prefluoridation.

Chemical and Physical Reactions in Water Heaters

J. Robert Popalisky

A paper presented on Sep. 28, 1954, at the Missouri Section Meeting, Jefferson City, Mo., by J. Robert Popalisky, Supt. of Purif., Water Dept., Kansas City, Mo.

IN general, the chemical and physical reactions often encountered in a water heater lead to both scale formation and corrosion, one of which will predominate. These scaling and corroding tendencies are affected by the constituents of the water, such as pH, dissolved mineral matter, and dissolved gases. Also important are: temperature; period of water retention; internal water velocities; pressure within the heater; basic construction materials; lining composition and application; and use of bimetallic couples in the heating system.

Corrosion Effects

Corrosion consumes the metals in a heater or converts them into useless compounds, weakening the tank structure. This deterioration can be of different degrees and types. Some of these are: grooving of the metal, by carbon dioxide dissolved in the water; pitting of the metal, by oxygen dissolved in the water; and generalized oxidation of the entire metal surface (less severe oxygen corrosion).

Chemical equations for the corrosion of iron are:

1. *Direct acid attack:*

$$Fe + H_2CO_3 \rightarrow FeCO_3 + H_2 \uparrow$$

2. *Oxidation in solution:*

$$4Fe + 3O_2 + 6H_2O \rightarrow 4Fe(OH)_3 \downarrow$$

3. *Direct oxidation:*

$$4Fe + 3O_2 \rightarrow 2Fe_2O_3 \downarrow$$

The products formed by the dissolved gases act as a protective coating for the metal underneath if the coating is left undisturbed. The products are very brittle, however, and do not flex with the metal under different pressures, nor do they expand and contract at the same rate as the metal under heating and cooling. Consequently, the corrosion products flake off, exposing bare metal to a fresh attack. Corrosion products are also subject to erosion under high-velocity use of hot water. The faster the water is run through the tank, the greater the erosion. Moreover, the water currents bring up fresh supplies of oxygen or carbon dioxide to promote further deterioration. The corroding process is also speeded up by higher temperatures.

Protective Linings

Hot-water storage tanks are subject to rapid corrosion unless the water is treated or the metal surface is protected in the form either of a heavy scale or an artificial lining. The inert inorganic materials generally used for tank linings include glass, silicates, enamel, and Portland cement. These materials are not affected by hot water. The active inorganic lining materials usually used are zinc, copper, or stainless steel. Of the three, zinc is by far the most commonly employed.

Zinc linings may be applied in four ways: by galvanizing, sherardizing, electroplating, or spraying. The thickness of zinc on steel usually varies from 0.625 to 1.375 oz per square foot of coated surface. The ability of the lining to stand distortion decreases with an increase in thickness. Galvanizing is probably the best method of application for water heaters, a thick, dense, well annealed lining being easily obtained.

Tests indicate that the rate of corrosion of zinc increases proportionately with the percentage of impurities present over a certain minimum. An ordinary practice in galvanizing is the addition of aluminum to the bath in order to increase the flowing qualities of the zinc and to give a more attractive appearance. Aluminum in excess of 0.1 per cent, however, can destroy the effectiveness of the zinc. Other metals can be equally deleterious.

Zinc, by itself, cannot be considered as a permanent lining for water heaters because of the harmful effects of water and substances in solution. Zinc is soluble in water at all pH values. Penetration into zinc varies from 0.20 in. per year at pH 3.0 to less than 0.0004 at pH 12.0. Although the pH value, in itself, is not particularly significant, it can become very important where adjustment in the pH may lead to mineral scale formation or dissolution.

Bicarbonate and hydroxide ions are a part of the water's mineral content that may be corrosive to zinc-lined heaters at high temperatures. The bicarbonates break down to normal carbonates and carbon dioxide dissolved in water or evolved as gas. This will make a direct acid attack on a heater, resulting in grooving. Hydroxides strongly dissolve zinc and break down to hydrogen and oxygen under localized high temperatures. The dissolved oxygen thus replenished goes on forming oxides of iron and zinc, while the hydrogen coats the metal surfaces.

According to Speller (*1*), this coating action is due to the overvoltage * of hydrogen where only one metal is involved. If different, adjacent metals —such as zinc and iron or zinc and copper—are both coated by hydrogen, however, the zinc will be heavily attacked and the adjacent metal will be protected. Where a metal high in the emf series and in overvoltage has electrical contact with another metal lower in the emf series and in overvoltage, hydrogen overvoltage no longer provides protection. Gas evolution takes place from the second metal, greatly increasing the corrosion rate of the first.

The overvoltage of hydrogen with respect to metals common in heaters is as follows (metals listed in emf series order): zinc, 0.75 v; iron, 0.27 v; nickel, 0.24 v; and copper, 0.33 v. Zinc would always be the metal that is attacked. Oxygen and carbon dioxide are liberated from solution upon heating and cause a direct attack on zinc, as indicated by these reactions:

Bicarbonate decomposition:

$$4HCO_3 + \text{heat} \rightarrow 2CO_3 + 2CO_2\uparrow + 2H_2\uparrow + O_2\uparrow$$

$$CO_2 + Zn \rightarrow ZnCO_3\downarrow$$

Source of hydrogen overvoltage:

$$H_2O + \text{heat} \rightarrow H + OH$$

$$2H + 2OH \rightarrow 2H_2\uparrow + O2\uparrow$$

Direct attack:

$$H_2O + CO_2 + Zn \rightarrow ZnCO_3\downarrow + H_2\uparrow$$

$$O_2 + 2Zn \rightarrow 2ZnO\downarrow$$

Continual removal of zinc oxide protective coating:

$$ZnO + CO_2 \rightarrow ZnCO_3\downarrow$$

$$ZnO + H + OH \rightarrow Zn(OH)_2\downarrow$$

* Overvoltage is the difference between the potential of an electrode at which a reaction is actively taking place and another electrode at equilibrium for the same reaction.

The maximum temperature reached in any part of the water heater has a direct bearing upon the protective quality of zinc. Both Schikor (*2*) and Speller show that, under certain conditions, zinc could become cathodic to steel and thus actually accelerate corrosion rather than retard it. It was found that, if the temperature of the water in a galvanized heater is 120°F or less, zinc does not become sufficiently cathodic to produce a couple with exposed iron. At a temperature as high as 150°F, the zinc becomes more cathodic, causing rapid corrosion of the iron.

Kenworthy (*3*), who studied the problem of copper and galvanized iron in the same heating system, concluded that the rate of corrosion of galvanized iron or zinc is materially increased by traces of copper in the water. The copper appears to deposit as small metallic particles on the surface of the zinc. Galvanic cells then form, with the copper particles as cathodes and the zinc surface as the anode. Sufficient copper can be dissolved by the simple passage of water through copper pipes to produce a noticeable effect upon the corrosion rate of zinc without an apparent loss of metal from the pipes. The amount of copper dissolved will depend on the composition of both pipe and water.

Cathodic Protection

If cathodic protection, such as by externally applied potentials or by galvanic coating, is used in connection with galvanized iron, the zinc can become nearly a permanent coating. Attention to the source of cathodic protection is all that is required; for example, a magnesium rod used as a sacrificial anode should be inspected twice a year and replaced when consumed. Cathodic protection installations may be of various types. As previously mentioned, rods or bags of magnesium can be used as sacrificial anodes, with a metal-to-metal connection to the tank or metal body to be protected. A nonsacrificial carbon electrode can be utilized, a controlled direct current, on the order of several volts and 0.25 amp, being applied to the carbon and the metal vessel. This arrangement does electrically what a sacrificial anode does electrochemically.

The significant factors in controlling the corrosion rate, or effective life, of galvanized-steel water heaters are: [1] the use of cathodic protection; [2] the composition and method of application of the zinc coating; [3] the temperature of the water; [4] the presence or absence of copper; and [5] the types of negative ions in the water.

Copper and stainless steel form comparatively durable coatings when electroplated to a substantial thickness on iron or steel. As these metals are also cathodic to iron, the coating must be continuous and free from pores. A very thin coating would be useless.

The results of recent studies indicate that, if zinc-lined heaters are to be used, the plumbing should all be galvanized. If copper plumbing is to be employed, the tank should be lined with an inert inorganic material or with copper. It is possible to protect galvanizing from copper by a galvanic cell and electrical insulation. This requires careful maintenance, however, and the expected life of the galvanizing is always in doubt.

The use of bimetallic couples in a heating system leads to rapid corrosion. In brass fittings connected directly to galvanized pipes, the copper would be cathodic and the zinc a sacrificial anode. Bimetallic couples must be electrically insulated. A plastic

pipe nipple specially designed for this purpose is on the market.

Scale Formation

Scale is formed by the deposition of the dissolved mineral matter from water. The worst effect of scale is its insulation of the water side of a heat transfer unit, leading to difficulty in heating the water. An accumulation of scale at any point can cause overheating of the metal at that place, resulting in rapid metal deterioration. Scale will reduce the inside diameter of the adjacent hot-water pipes and can also be the indirect cause of severe localized corrosion. The expansion coefficients of metals and scale compounds are not the same. This leads to checking or flaking off of the scale, exposing small sections of bare metal.

Scale formation can occur as a soft sludge, which will pile up on the bottom of the heater, and as a firm, but presumably soft, coating or extremely tenacious, hard scale on the sides of the heater or in adjacent pipes.

The more common dissolved mineral constituents are: calcium bicarbonate, calcium carbonate, magnesium bicarbonate, sodium bicarbonate, calcium sulfate, magnesium sulfate, sodium sulfate, magnesium chloride, sodium chloride, sodium nitrate, and silica. Of concern in the heating of water are the compounds of calcium, magnesium, and silica. In domestic water heaters, calcium carbonate ($CaCO_3$) and a hydrated magnesium silicate ($3MgO \cdot 2SiO_2 \cdot 2H_2O$) comprise the bulk of every scale formation, except for corrosion products. Other scale compounds occur at temperatures and pressures not ordinarily reached in domestic water heaters. Two factors, pH and temperature, affect the degree to which the carbonate and silicate precipitate in domestic water heaters.

The most common cause of scale is the decomposition of calcium bicarbonate into calcium carbonate by heat. The solubility of calcium carbonate decreases at elevated temperatures: at 140°F it is 42 ppm, and at 180°F 30 ppm. The equations for these reactions are:

$$Ca(HCO_3)_2 + \text{heat} \rightarrow CaCO_3 \downarrow + H_2O + CO_2 \uparrow$$

$$CaCO_3 + \text{heat} \rightarrow CaCO_3 \downarrow$$

The form that this precipitation takes will depend upon the degree of temporary hardness, the time the water is retained in the heater, the temperature reached in any part of the system, the amount of water drawn off, the pressures exerted, and the structural characteristics of the heater. This type of scale trouble is not very bad when the temporary hardness is less than 75 ppm, but, when greater, deposition of scale becomes a serious problem.

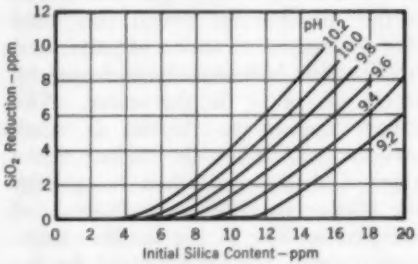

Fig. 1. Silica Removal and pH

The effects of pH on silica removal (and, hence, on scale formation) from water at 140°F are charted here.

The other form of scale—hydrated magnesium silicate—occurring in heaters is mainly dependent upon the pH of the water, but its rate of formation is directly proportional to the temperature. In domestic water heaters, this reaction does not occur appreciably if either the silica or the magnesium con-

tent is less than 2.0 ppm. Magnesium or silica can form a scale by itself, but only under certain unusual conditions.

As hydrated magnesium silicate is composed of approximately equal parts of magnesium and silica (43.7 per cent magnesium, 43.4 per cent silica, and 12.9 per cent water), this condition can be dealt with from the standpoint of either magnesium or silica. Figure 1 charts the effect of pH and the initial silica content of the water on the formation of this scale at 140°F. With an initial silica content of 14 ppm, at a pH of 10.2, 8.5 ppm silica would be precipitated; at a pH of 9.3, 1.5 ppm silica would be precipitated. With sufficient magnesium present, an equal amount of hydrated magnesium silicate would be removed.

TABLE 1

Crystalline-Scale Constituents

Scales	Constituents
Aconite	$Na_2O \cdot Fe_2O_3 \cdot 4SiO_2$
Anhydrite	$CaSO_4$
Brucite	$Mg(OH)_2$
Cancrinite	$4Na_2O \cdot CaO \cdot 4Al_2O_3 \cdot 2CO_2 \cdot 9SiO_2 \cdot 3H_2O$
Noselite	$4Na_2O \cdot 3Al_2O_3 \cdot 6SiO_2 \cdot SO_4$
Serpentine	$3MgO \cdot 2SiO_2 \cdot 2H_2O$
Xonotlite	$5CaO \cdot 5SiO_2 \cdot H_2O$

Magnesium silicate is a complex crystalline compound. The presence of trace elements, such as aluminum, is likely to result in the formation of a more complex scale. The actual chemical composition of this type of scale can be identified by X-ray diffraction only. Table 1 lists the results of several such analyses. The precipitation of the scale generally takes place in the pipe immediately adjacent to the heater, or at any point in the heater where boiling may occur, owing to structural characteristics or sludge accumulation blanking.

Conclusion

The critical water temperature in domestic water heaters is about 140°F. At this point physical and chemical reactions are slow, but above it they become very rapid. It is not necessary to go beyond the critical temperature to obtain sufficient hot water if adequate storage is provided. The water entering the heater should have slight tendency to deposit calcium carbonate. For this, a 0.4–0.8 Langelier stability index and a temporary hardness of less than 75 ppm are desirable. The scaling conditions caused by compounds other than calcium carbonate in the water must be carefully controlled.

Corrosion in water heaters can be controlled through the use of proper construction materials and good structural design. Where it is necessary to have temperatures in excess of 140°F, treatment for scale prevention must be provided.

The author believes that the control of domestic water heater installations should be in the hands of the water works industry. The consumer then would be sure of the best possible hot-water service.

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New Jersey Licensing and Tenure Laws

Kenneth J. Carhart and Robert S. Shaw

A paper presented on Nov. 5, 1954, at the New Jersey Section Meeting, Atlantic City, N.J., by Kenneth J. Carhart, Chief, State Bureau of Examination & Licensing, Trenton, N.J., and Robert S. Shaw, Chief Public Health Engr., State Dept. of Health, Trenton, N.J.

NEW JERSEY, a pioneer in the field, has been licensing water treatment plant operators since 1918 and water supply system operators since 1938. A basic reason for licensing is the protection and preservation of the public health, safety, and welfare. So that the owners or managers of public water works may secure the services of capable superintendents or operators, the State Dept. of Health holds license examinations at least twice annually. These are conducted by persons appointed by the state and held at a designated place under official regulations for determining the qualifications of applicants.

Requirement of License

State law prohibits anyone from functioning as the superintendent or operator in charge of a public water supply or treatment plant unless he is the holder of a license issued by the State Dept. of Health. The terms "superintendent" and "operator" mean any person (whatever his local title) who is in direct general charge of a public water works and is responsible for supervising the condition, operation, and effectiveness of its facilities, as well as for the safety or quality of the finished water. A public water works is defined as one which treats or supplies water for consumers in twenty or more dwellings or properties.

The state health department regulations for the administration of the licensing law have been revised from time to time to meet changing conditions. The latest set of regulations became effective Sep. 25, 1953. Examinations for licenses are prepared, conducted, and graded by a group of persons known as the Board of Examiners, composed of nine members. Three of these are employed in the health department Bureau of Public Health Eng. Another three are superintendents or operators who have at least 5 years' experience in the operation of public water works, and possess a first-class water treatment plant license or a Group One water supply system license. The remaining three board members are superintendents or operators with at least 5 years' experience in the operation of public sewage treatment plants and possessing at least a Grade A license.

Examination Applications

Applications for admission to examinations are made on forms furnished by the health department. The forms must be filed with the Bureau of Examination and Licensing not later than Apr. 10 and Nov. 10 of each year in

order to be reviewed by the Board of Examiners sufficiently in advance of the examination date. Admission to examination is dependent upon the information furnished in the application, which must be accompanied by documentary evidence in support of claims of educational and experience qualifications.

Educational credit is given for college training, technical-college degrees, and the possession of a New Jersey professional engineer's license. Credit is also given for special technical or practical studies pursued in vocational schools, college extension courses, and operators' short courses (held at Rutgers University and the Camden County Vocational School).

Credit is given for full-time experience obtained in the actual operation of a utility like the one for which an applicant desires to acquire a license. Some credit may be given for experience in allied lines of work. In-service training under a qualified superintendent or operator may also be credited as full-time experience. This is possible when a person holding a proper license secures permission from the State Dept. of Health to supervise the operation of a water supply system or treatment plant in addition to his primary employment. In that fashion, a plant needing a licensed operator complies with the law, and a prospective operator gains the required experience under a qualified person. The health department holds the supervisor responsible for the satisfactory operation of the plant or system until the trainee has obtained a license and is officially placed in charge. This is a valuable section of the regulations, as it enables owners of water works to secure qualified, licensed supervision quickly in the event of the unexpected loss of the regular superintendent or operator.

License Classifications

For licensing purposes public water supply systems are classified into four groups, based on the volume delivered (Group One is the highest, Group Four the lowest). A special classification, Group S, applies to all systems with not more than approximately 50 services, and to other systems that the health department may not regard as requiring a higher license classification.

The five classifications for public water treatment plants are based on the following factors: [1] method or degree of treatment; [2] daily volume to be treated; and [3] source of supply. The lowest classification, fifth class, applies only to plants treating less than approximately 25,000 gpd for a public school.

Revisions of the licensing regulations are made with the proviso that the status of the holder of any license issued prior to the adoption of the new rules will not be affected. Thus, an operator is protected if the classification of license required for the operation of his plant is revised upward.

License Fees

The license fee is $5.00 per year, $2.00 of which must be submitted with the application for admission to examination, the balance being paid upon successful completion of the test. Should the health department deny the issuance of a license to any applicant (or refuse him admission to the examination), the initial fee of $2.00 is not returned.

All licenses expire on Sep. 30 of each year. Renewal may be made at any time during September by payment of a fee of $5.00. The failure of

a licensee to renew in September does not deprive him of the right of renewal, but he must pay a $1.00 penalty for every three months of delinquency. Licenses not renewed within 2 years from the date of expiration are automatically revoked.

Revocation and Tenure

The public is protected against the negligence of licensed superintendents or operators who become lax in the performance of their duties in the power of the Dept. of Health to revoke licenses under certain conditions.

The license holder is also protected, because revocation of a license can be accomplished only after a hearing held by the health department. The licensee must have an opportunity to be heard either in person or by counsel. It must be determined that the superintendent or operator is incompetent, that he has willfully neglected his duty, or that he has disregarded or disobeyed lawful orders or regulations of the health department before a license may be revoked. The hearing assures both the state and the licensees equal opportunity to present their case. Revocation proceedings against licensed operators are rarely necessary, and few licenses have been revoked.

An outstanding feature of the licensing law is its tenure provisions. A person with 5 years of consecutive service in general charge of the operation and maintenance of a publicly owned water works facility may not be removed or subjected to a salary reduction except for good cause and after a public hearing. A public board, officer, or commission which has the power to appoint a successor to such a person must arrange a hearing. The defendant must receive a written copy of the charges and must be notified of the time and place of hearing at least 5 days in advance.

The officials in charge of a hearing are responsible for determining if the accusations are justified. The entire process is designed to protect water works employees from the effects of political changes. The public is also benefited in that continuity of capable operation of publicly owned water works is assured.

The basic function of the licensing law is to protect the people's health, comfort, and property by requiring adequate and competent supervision of all public water works. Although the New Jersey law has been challenged in the courts, it has been upheld in all its provisions.

Development of the California Water Plan

C. A. Griffith

A paper presented on Oct. 29, 1954, at the California Section Meeting, Long Beach, Calif., by C. A. Griffith, Chairman, State Water Resources Board, Azusa, Calif.

LEGISLATION enacted in 1947 authorized the California Water Resources Board to restudy and bring up to date the State Water Plan prepared by the State Div. of Water Resources in 1930. The board, with the technical assistance of that division, has since carried out complex and detailed in- California. First a complete inventory vestigations of the water resources of of the water resources of the state was made. Next came a detailed study of present water utilization, including the classification of all irrigable and habitable lands in California. On the basis of this study, the future water needs have been estimated for every part of the state. The third phase of the study is the formulation of a plan for the full practicable development, control, and utilization of water resources throughout the state. That is quite an undertaking. It involves bringing water to every irrigable and habitable acre in California. It involves flood control in regions where excess waters go to waste. It involves the generation of hydroelectric power in controlling these excess waters. It involves new water supplies for irrigation, domestic, and industrial use. It involves salinity control on such major rivers as the Sacramento–San Joaquin system. It involves replenishment of depleted underground reservoirs and repulsion of sea water from coastal basins. It involves preservation of fish, wildlife, and recreational resources. In fact, it involves something specific with regard to water conservation, control, protection, and utilization for every area in California.

Such a plan may seem very much like an attempt to create Utopia. If the plan were complete and could be executed all at once, California would indeed resemble Utopia, insofar as water conditions are concerned, although there probably would be several thousand pending lawsuits regarding the distribution of water resources in this Utopia. It must be said in cold reality, however, that the California Water Plan, as presently envisioned by the engineers of the State Div. of Water Resources, will probably never be completely realized. Nevertheless, certain phases of it are now physically and economically feasible, and some of these will be discussed in more detail later.

Hydrologic Regions

Climatically and geographically, California is a jigsaw puzzle which has been scattered by the careless hand of

Fig. 1. California Hydrologic Regions

1—North Coastal Area; 2—San Francisco Bay Area; 3—Central Coastal Area; 4—South Coastal Area; 5—Central Valley Area; 6—Lahontan Area; 7—Colorado Desert Area.

nature over approximately 700 miles of the Pacific Coast. The major sources of water are located where they can conveniently waste into the ocean unused. The great productive land areas are placed where water supplies are insufficient. There are desert areas that could be made into a veri-

table Garden of Eden, if water could be brought to them. And complicating this jigsaw puzzle of land and water are intervening mountain ranges.

For the purposes of developing the California Water Plan, the state has been divided into seven hydrologic regions (Fig. 1). Region No. 1, the North Coastal Area, comprises 19,586 sq miles of largely mountainous lands containing almost 41 per cent of the state's annual water supply in the form of precipitation and runoff. The annual average runoff amounts to about 28,886,000 acre-ft. Region No. 2, the San Francisco Bay Area, with 4,409 sq miles of land, has a total of only 1.8 per cent of the annual runoff. Region No. 3, extending down the coast from Santa Clara through Santa Barbara County, has 11,284 sq miles of land and 3.4 per cent of the state's annual runoff. Region No. 4, stretching south from Santa Barbara County to the Mexican Border and east from the coast to the divide of the Coast Range, has 10,955 sq miles of area, about 50 per cent of the state's population, and only 1.7 per cent of the annual runoff. Region No. 5, the great Central Valley Basin, extends south from Modoc County to the Tehachapi Range and east from the Coast Range to the Sierra Nevada. It comprises 59,424 sq miles and has 47.5 per cent of the annual runoff, or a total of 33,637,000 acre-ft per year, on the average. Region No. 6 takes in all of the area east of the Sierra Nevada, from Modoc through San Bernardino County. Its area is 32,907 sq miles and it receives 4.5 per cent of the total runoff. Region No. 7, the Colorado Desert Area, includes 19,730 sq miles of land and has only 0.3 per cent of the state's runoff.

Early Developments

From a nontechnical standpoint, the problem of equalizing California's land and water resources is relatively simple. It boils down to taking the water from where it is to where it isn't. That principle was followed in all of the early water developments. At first it was merely a matter of diverting water from a stream to the adjacent lands. Soon it became necessary to go upstream and impound winter surpluses, building major dams, reservoirs, and water transportation systems. Linked with these was the development of hydroelectric power. And, with hydroelectric power, came improved pumps that made it possible to reach into the vaults of the earth to tap the waters stored there.

Each of these steps has filled a gap in the state's ever growing water needs, but each, in turn, has proved insufficient. With virtually all of its local water supplies developed, Los Angeles went to the Owens River for additional water. Then major areas in Southern California formed the Metropolitan Water Dist. and sought their supply from the Colorado River. Meanwhile San Francisco and Oakland went to the High Sierra for their water. Although these projects, stupendous as they were, filled a particular need for a limited period, they did not solve the state's water problem. The Central Valley Project, designed to deliver supplemental water from areas of surplus in the Sacramento Valley to areas of deficiency in the San Joaquin Valley, likewise is intended to fill a specific need. This project is only a magnification of what more than 100 irrigation and reclamation districts did on their own, with

local financing. Without these projects, California, for the most part, would still be a semiarid wasteland, but all of them represent local and piecemeal planning.

The principle of an overall water plan has long been recognized. In 1872 a general water development plan for the great Central Valley was conceived by private enterprise. The California Canal and Irrigation Co. proposed to construct a grand canal along the east side of the valley from Red Bluff to Bakersfield and another canal extending from Red Bluff along the west side of the valley. In 1919 Robert B. Marshall, who had served for many years as chief geographer in charge of the topographic branch of the US Geological Survey, presented a plan that contemplated a system of canals skirting the entire rim of the Sacramento and San Joaquin valleys, fed by a system of storage reservoirs which would conserve and regulate waters then wasting into the ocean. Although the idea of an overall water plan is not new, the methods of putting it to practical application have been far from clear or coherent.

Feather River Project

The Feather River Project, authorized for state construction by the legislature in 1951, is actually the first statewide project ever proposed for California. It can be considered the keystone of the California Water Plan, and all future development will either supplement or parallel this proposed method of moving water from areas of surplus to those of deficiency. This project uses the delta area, where the Sacramento and San Joaquin rivers join in a great inland pool at sea level, as the fulcrum in moving water from north to south. In this respect, the Feather River Project differs from earlier plans. It follows the principle of the Central Valley Project as originally conceived by the state engineer in 1930, but it is designed to deliver water outside of the Sacramento and San Joaquin valleys, which was never envisioned in the Central Valley Project.

Because of its great importance in all future water developments in California, it is worth while to describe briefly the major features of this unsupply for the project will be prodertaking. Primarily, the new water vided by a dam and reservoir on the Feather River about 5 miles above Oroville. The dam, as proposed, will be the largest in the United States. It will reach a height of 710 ft above the stream bed and will be 5,040 ft long. The reservoir, of 3,500,000 acre-ft capacity, will, when operated in conjunction with the delta pumping lifts and the San Luis Reservoir, make available 4,000,000 acre-ft of water for export to the Santa Clara Valley, the west side of the San Joaquin Valley and the area south of the Tehachapis, in addition to providing 970,000 acre-ft of water for the Feather River Service Area in the Sacramento Valley. Falling water at the dam will be used to generate about 1.75 billion kilowatthours of electric energy.

The present Feather and Sacramento stream systems will be used as the channels for delivering water to the delta. There, Feather River water and other excess flows will be picked up at pumping plants for the journey southward. The first diversion, by pumping lift and tunnel, will provide 245,000 acre-ft of water to

areas in Alameda, Santa Clara, San Benito, and San Mateo counties.

The San Joaquin Valley unit of the project will comprise a 6,000-cfs canal, pumping lifts, and a proposed storage reservoir of about 2,000,000 acre-ft capacity on San Luis Creek. This unit will provide approximately 2,000,000 acre-ft of new water for use on the west side of Fresno, Kings, and Kern counties and deliver water to the Southern California portion of the project.

The Southern California unit, with pumping plants at Pastoria Creek in Kern County, would lift water from the San Joaquin unit to el 3,357 and into 10½ miles of tunnels through the Tehachapi Mountains. Several other possible routes through the Tehachapis are under study. Regardless of the final determination of the route to be used, it is planned to deliver about 1,780,000 acre-ft of new water through a system of canals and tunnels extending as far south as the Mexican border.

It is presently estimated that the project will cost $1,500,000,000. The state engineer is now preparing a report, for the 1955 session of the legislature, containing a proposed step-by-step construction program and suggesting methods of financing it. This is the first real move by California, as a state, since 1933 in undertaking the financing, construction, and control of its future major water developments, with the federal government participating only to the extent of its interest in such matters as navigation, flood control, and the preservation of fish, wildlife, and recreational resources.

Future Needs

Even though the Feather River Project will bring approximately 4,000,000 acre-ft of water to areas of deficiency throughout the state, it is far from the final answer to California's water problems. One report that the State Water Resources Board hopes to present in completed form during the 1955 session of the legislature includes certain findings on present and ultimate water uses. In 1954 the population of California was more than 12,000,000. The annual increase is nearly 370,000. Someday, of course, it will reach a saturation point. By 1980 it is estimated that the population of California will be 21,000,000.

The present use of water in California for all purposes is estimated to be about 24,000,000 acre-ft per year, which exceeds the safe yield of developed water supplies by about 3,000,000 acre-ft per year. In other words, the water situation is very much like the national debt. The accumulated water deficiency under present conditions is increasing at the rate of 3,000,000 acre-ft annually. The board's studies show that, taking into consideration the use of return flows, it will require about 51,000,000 acre-ft per year to meet California's probable ultimate requirements, a figure that is 30,000,000 acre-ft greater than the safe yield of presently developed supplies.

The average annual ultimate surplus of water in the state's areas of excess—the North Coastal Region and the Sacramento Valley—is estimated to be about 41,000,000 acre-ft, not including 5,500,000 acre-ft which may be developed for future use in these two areas. Of this estimated 41,000,000 acre-ft of surplus water, studies indicate that it will be possible to salvage and put to use about 21,000,000 acre-ft annually for export to areas of deficiency. About 11,000,000 acre-ft of this water

must come from the North Coastal Region, and the remainder (10,000,000 acre-ft), from the Sacramento River Basin, would be available in the Sacramento–San Joaquin Delta.

Increased imports of Colorado River water up to California's rights in the amount of 5,362,000 acre-ft annually and possible further development of new water in areas of deficient supply would make available the remaining 3,500,000 acre-ft annually. Thus, it appears that enough water can be made available for California's future needs. This objective will require the construction of many large multiple-purpose dams, particularly in the Sacramento Valley and the North Coastal Region, as well as the rational utilization of the state's large ground water storage basins and their coordinated operation with the surface reservoirs to be created.

The relatively great importance of ground water resources in California's plans to meet its future water requirements should be emphasized. Shasta Reservoir, on the Sacramento River, will store 4,500,000 acre-ft of water. By comparison, the ground water storage capacity within 200 ft of the surface in the Sacramento and San Joaquin valleys has recently been estimated by the US Geological Survey at more than 130,000,000 acre-ft. This vast regulatory reservoir is available for use if the engineerineg and legal problems connected with its planned operation can be solved.

Water Supply Structures

In studies leading up to the formulation of the California Water Plan, the state's engineers investigated literally hundreds of dam sites on the rivers feeding into the Central Valley Basin and on those now wasting their waters into the Pacific in the North Coastal Area. The method of impounding and utilizing waters in the Central Valley Basin is well established and requires only amplification.

As early as 1930 the state proposed the first transmountain diversion from the Trinity River to the Sacramento Valley Basin. The federal government has accepted this principle of diversion and is now urgently seeking congressional authorization for the construction of its Trinity River Project. California's studies have shown that virtually all water conservation in the North Coastal Area will more or less parallel the principle of the Trinity River Project. The present plan for transfer of Trinity River water to the Sacramento River watershed is relatively simple. It involves only the construction of a dam and transmountain diversion tunnels, which, linked with the hydroelectric power drops that can be developed, will make this project valuable for the water it can supply in the Sacramento Basin and for its hydroelectric power.

Future developments in the North Coastal Area will be more complicated. In addition to dams, power plants, and transmountain diversion tunnels, pumping lifts will be needed. The rivers of this area are a great storehouse of undeveloped hydroelectric power. If this potential is realized, there will be sufficient power for the pumping plants necessary to lift surplus waters from the lower reaches of the coastal streams to elevations where they can be diverted through the Coast Range, with a backlog of power remaining to assist in paying for these projects.

Financial Problems

The matter of financing future water developments is highly important. As previously mentioned, the state engineer proposes to present to the 1955 legislature a plan for financing the Feather River Project. If approved by the legislature, this plan may well set the pattern for the financing of future projects in the state. There is, of course, great pressure upon the legislature to provide funds for other needs, such as schools, highways, and social welfare agencies. The members of the legislature are to be complimented for the excellent manner in which they are dealing with the innumerable problems confronting them in a state growing as rapidly as California is. Probably in no period in its history has the state been faced with so many acute problems requiring immediate solution. The legislature has had great foresight and been most generous in providing funds to the State Water Resources Board for the investigations leading up to the California Water Plan. The board recognizes, however, that, regardless of the adequacy of its planning, the water needs of California cannot be met unless means of financing these proposed projects are devised. It is the hope of the board that the legislature will give the same serious consideration to this problem at its 1955 session that it has given to the planning phase in solving statewide water problems.

Some Legal Aspects of Ground Water and the California Water Plan

Henry Holsinger

An address presented on Oct. 29, 1954, at the California Section Meeting, Long Beach, Calif., by Henry Holsinger, Prin. Attorney, Div. of Water Resources, State Dept. of Public Works, Sacramento, Calif.

CALIFORNIA, although richly endowed with natural water supplies, is subject to an unfortunate imbalance in distribution of this limiting resource, geographically and seasonally. About two-thirds of the total precipitation occurs in the northern part of the state, whereas the greatest agricultural, industrial, and municipal demands are in the central and southern portions. Further, the greater percentage of the total runoff does not occur within the annual periods of greatest demand. Therefore, artificial regulation of stream flow by storage, in order to supply the water required during the dry summer and fall periods, and redistribution of water supplies from areas of surplus to areas of deficiency, constitute the basic water problem of California. The solution of this problem necessarily involves extensive transportation of water from the northern part of the state to the central and southern portions. For some years past, the office of the State Engineer and Chief of the Div. of Water Resources, acting under direction of the State Water Resources Board, pursuant to appropriations made by the legislature, has been actively engaged in the preparation of the California Water Plan, with the objective of devising an acceptable solution of this basic water problem. It is inherent in such solution that construction of numerous surface storage reservoirs will be required. However, if it were necessary to place reliance solely upon surface reservoirs for the necessary storage capacity in order to make those plans effective, their feasibility might well be subject to question.

On a statewide basis, roughly 50 per cent of the water applied to beneficial use in California is derived from ground water. In some of the more arid sections of the state, ground water constitutes at present the only dependable source of supply. There are within the state numerous ground water basins which have in the aggregate a vast storage potential. It is obvious that if a part of this storage potential can be utilized for purposes of the California Water Plan, it would be unreasonable to incur the enormous expenditures required for similar storage capacity in surface reservoirs, even though feasible sites could be found. The expense of utilizing ground water storage for the great purposes of the plan would obviously be a small percentage of the cost of the same storage capacity in surface reservoirs.

So far reference has been made to "potential" ground water storage.

Not until partially depleted does potentiality become reality. Therefore, ground water storage is potential only until the basin is sufficiently drawn down to afford the required storage capacity. Thereupon the potential becomes actual storage capacity. It is the consensus of opinion of qualified engineers who have adequately reviewed the subject, that it would be feasible to utilize for purposes of such plans a portion of the vast potential storage capacity of existing ground water basins to establish the necessary carryover storage in order to assure adequate supplies of water during an extended period of deficient precipitation and runoff.

The following statement has been repeated many times in public addresses by the State Engineer and members of his staff:

> . . . I wish to emphasize that the estimates of the ultimate water requirements of the entire state so far made, indicate that adequate water supplies can be developed and regulated from California's water resources, including California's rights in and to the waters of the Colorado River, in available surface reservoir sites and ground water basins to meet the probable ultimate water requirements in the state without resorting to the importation of water from an outside source such as the Columbia River in the Pacific Northwest.

To accomplish the necessary regulation, conservation, and utilization of the state's water resources at reasonable cost will therefore require the planned utilization of ground water basins. Available surface storage capacity, carefully integrated in operation with adequate ground water storage capacity, would afford the necessary cyclic storage for protection against a series of years of deficient precipitation and runoff. It would also enable the full application to beneficial use of the irregular surface inflow from tributary mountain areas, both for local use and for exportation from areas having a surplus water supply to areas of deficiency. Such planned utilization of ground water basins would require that, upon the termination of a period of subnormal precipitation and runoff, the agency in charge of the operation of the plan should promptly recharge to a satisfactory level all such basins which had been drawn upon. They would then again be available if and when another period were encountered of inadequate precipitation and runoff. A major contribution of the available surface storage would be to make possible the necessary artificial recharge of the ground water basins.

Under the California Water Plan the fullest practicable development, conservation, control, protection, and utilization of all water resources in all areas of the state is planned. Local ground water resources must therefore be developed to the fullest practicable extent, and available ground water storage capacity must be utilized for cyclic storage not only for local waters but also for imported waters. Maintenance of utility of ground water basins is therefore essential to the California Water Plan.

Planning for statewide development of water resources is necessarily based on the assumption that history will repeat itself. This is self-evident. We all hope, of course, that a succession of dry years such as were experienced in the period 1923–24 to 1933–34 will never be encountered again; however, it would be completely unrealistic to base the required long-range planning on any such assumption. One of the critical points in statewide planning is therefore the formulation of effective means to provide adequate carryover

storage in order to meet demands during future years of deficiency at least as great, if not greater, than in periods encountered in past recorded history. The indicated feasible means to do this is to integrate with care available surface and ground water storage. This would call for extensive drawdown of strategic ground water basins in time of need. It is not feasible to do this under current applicable principles of law.

Ground Water Legislation

Although ground water is of equal importance with water occurring on the surface, there are but two situations where jurisdiction is presently vested in the State Engineer to administer acquisition of appropriations of ground water. These are as follows: [1] where the appropriation is made from a subterranean stream flowing through a known and definite channel; and [2] where the appropriation is made of water consisting of part and parcel of the "underflow" or "supporting flow" of a surface body of water. Where these situations do not exist, an appropriation of "percolating water" under existing law may freely be made without state approval or supervision of any nature. The reason for the omission of ground water from the statutory authority is believed to lie in the failure at the time the law was first enacted (1913) to comprehend its immense importance. That comprehension came only of comparatively recent years.

In order that the power to draw down ground water basins may be utilized, it must be conferred by legislation or constitutional amendment, or both. Further, it could be made effective only by carefully devised statutory provisions with adequate safeguard for interests adversely affected. Such legislation would appear to necessarily involve state regulation and control of the appropriation and utilization of ground water.

These suggestions require consideration of the feasibility of such a system of ground water control in this state. The broad question presented is whether statutory provision for state administration of and control over the extraction and use of ground water, if and when challenged before the courts, would be upheld. Assuming such authority were accompanied by adequate safeguards to protect existing rights of all water users, there should be no substantial question as to validity. In view of the magnitude of the interests involved, however, common prudence would require that the groundwork be laid for the necessary statutory enactment, by the adoption of a constitutional amendment. No thought whatever is entertained of any disregard of vested rights. However, in view of the great public interest involved in the California Water Plan, it is believed that interests adversely affected by operation thereof should be relegated to remedies restricted to compensation either by delivery of water or by payment in cash.

The history of prior sessions of the California legislature indicates that at each of two prior sessions, 1917 and 1923, bills were introduced with the objective of subjecting ground water to the permit and license system now applicable to surface streams and bodies of water, but no action was taken on either bill. In 1941, pursuant to a request of a member of the legislature, the Legislative Counsel drafted a proposed statute having similar effect, but no bill on the subject was introduced at that or subsequent sessions. In

none of these proposals, however, was there any express authority for an appropriator of ground water to engage in extensive drawdown of ground water levels. The current status of case law on the subject indicates that such drawdown probably would be approved to some extent, but doubtless not to the extent required for the contemplated purposes.

As near as the statutory law of California now approaches the subject is Section 1242 of the Water Code, which authorizes the appropriation of water for surface storage for the purpose of release and diversion of the water for spreading the same and inducing percolation thereof, and the subsequent extraction of the water and application to beneficial use. So far there has been no judicial examination of this section, and it remains to be seen to what extent it will prove effective.

It would therefore appear that in some form effective means of ground water utilization and control will be necessary in order to implement current plans for statewide water development, but there exists no precedent in this state for legislation to the effect here suggested.

In a search for precedent as to what might be done, it is informative to consider what legislation has been enacted on the general subject in other states. It is to be expected that it would be difficult, if not impossible, to find any direct precedent. In order to do so it would be necessary to look to the laws of a state which had enacted precisely the same character of a statute as here suggested, and against a background of the same relationship between riparian rights and appropriators, and overlying rights and appropriators, as prevails in California.

Some of our neighboring western states do not recognize the riparian doctrine at all, and none presently recognize our doctrine of correlative overlying rights. Others have favored the extension of the appropriation doctrine until riparian rights, although still nominally in existence, have little practical significance. The logical area, therefore, to look for precedent is to eastern states where the riparian doctrine is still in full force. However, the eastern states either do not have the appropriation doctrine superimposed on the riparian doctrine, or they have no ground water legislation of the nature contemplated. Neither do any of them follow our correlative doctrine of overlying rights. Therefore, the only precedent we have for the proposed state control of ground water is in states whose case law is not only not similar to that in California, but in some respects in contrast with it. These considerations greatly minimize the weight of the statutes of all such states as precedent. We therefore must conclude that California is unique respecting its law relating to ground water and there is no direct precedent in other states for the proposals here suggested in regard thereto.

Adequate protection of our water resources can only be achieved through control and regulation by the state of the water withdrawn from ground water basins, including supervision over recharge of depleted basins. To accomplish these objectives basic statutes are required authorizing: [1] the requirement of permits and licenses for the appropriation and use of ground water authorizing extensive depletion of ground water levels when required; and [2] control and supervision of recharge of depleted ground water sources.

In the event of grave danger or permanent injury to the source of supply, it would be necessary to impose limitations upon then existing extractions. However, due to the prospect that imposition of any such restrictions might well have adverse economic effects of great magnitude, it is believed that no administrative officer or agency should be authorized to impose such a harsh remedy, and therefore that such remedy should be vested in a court of competent jurisdiction. This calls for the careful review of existing procedures to ascertain their adequacy for the purpose of adjudicating ground water rights.

Preliminary Conclusions

The following preliminary conclusions relative to ground water adjudications appear to be warranted:

1. The boundaries of ground water basins can be determined only after competent and thorough geologic and hydrologic investigations.

2. The safe yield of a ground water basin is not a fixed quantity but varies with (among other factors) the state of artificial development in the basin and in the watersheds tributary thereto. Periodic redeterminations must be made accordingly of the allowable extractions from the basin.

3. It will invariably take a considerable period of time and substantial expense to obtain the data necessary to determine the safe yield of a basin.

4. Experience has indicated the advisability of compiling basic data required for adjudication over a period of years beginning long prior to initiating an adjudication, so that when the need therefor arises, the required data will be available for use.

5. Provision for recordation of records of ground water use would appear to be salutary, as in time it would afford a ready source of highly relevant information. It is also recognized that some incentive must be afforded to induce the filing of these statements of use. However, it is believed improper to accord prima facie effect in evidence to such statements in the absence of adequate provision for verification of the accuracy of the facts stated.

6. In many instances it would be difficult to establish that excessive extractions have resulted in irreparable damage to a basin. Some basins can be pumped dry for all practical purposes without irreparable damage resulting, for upon cessation of pumping, the basin may gradually refill with water of satisfactory quality by natural processes. On the other hand, where compaction and subsidence occurs, or in coastal ground water basins where sea water intrusion occurs due to overdraft, or in other special cases, a finding of irreparable damage might be made.

7. It is believed unwise from a public policy standpoint to require cessation of pumping upon a finding of overdraft unless a source of supplemental water is immediately available. This would seem unavoidable due to the adverse economic effect which might follow from abrupt enforced cessation of extractions. The objective should, however, be retained to improve the yield, by importing a supplemental supply, in order to bring into balance extraction and yield. Such balance should be sought by limitation of extractions only as a last resort, when no other feasible recourse is available, and for the purpose of preventing irreparable damage to the source.

8. Rather than casting the burden of limiting extractions to the safe yield

upon an administrative officer, it would appear preferable to improve existing available procedures for adjudication of rights to the use of ground water.

There appears to be a growing appreciation of the interrelationship between ground water and surface water. This interrelationship, of course, is generally well understood by the initiated few, but it is not evident that public recognition thereof is at all widespread. It is true, of course, that with great frequency a surface flowing stream is either in major part fed by ground water sources through which it flows or the surface stream directly contributes to the ground water body. No demonstration should be required in order to establish the need for coordination of rights to the use of interconnected supplies. At present the sole means of securing such coordination is through the process of adjudication.

Court Reference Procedure

The State Engineer may participate in the adjudication of rights to ground water under the court reference procedure only upon the exercise of discretion by the trial court in acting upon a motion to order a reference to the State Engineer of a pending cause involving determination of such rights. The practice is to limit the reference to investigation and determination of the physical facts and to report thereon to the court. This procedure has been resorted to so far in but two instances where the cases concerned ground water only.

Some dissatisfaction has been expressed as to the costs involved and to the periods required to complete the investigations and render the reports. An impression appears to prevail in some quarters that both cost and delay were due to the procedure followed. This impression is far from the actual fact. The two instances heretofore given have reference to the court reference procedure in ground water cases followed in the Raymond Basin Reference which eventually resulted in the decision of the Supreme Court of California in *Pasadena* v. *Alhambra*, 33 Cal. 2d 908, and the West Coast Basin Reference, in which the report of the State Engineer as referee has been filed with the trial court and proceedings are pending thereon. True, in both cases extended periods were required for investigation and formulation of the report. It is also true that the attendant expense in both cases was heavy in the aggregate. Nevertheless, neither the period required for the investigation and report nor the heavy expense were due in any material respect to the procedure followed. To the contrary, both expense and delay were due to the inherent nature of the subject matter. Surface bodies of water can be visually inspected and, as contrasted with ground water, the characteristics of occurrence, draft, depletion, and other required factors can usually be readily determined; not so with ground water. The essential facts required for determination of any controversy respecting ground water characteristics, availability, and use can only be determined by high quality of engineering talent through long and patient effort; and, furthermore, the ultimate facts must be presented in open court to a large degree by expert opinion evidence. Both expense and delay are therefore unavoidable, irrespective of the procedure followed. By this, however, no inference is intended that savings in both time and expense cannot be accomplished by improving procedures—quite the contrary.

The court reference procedure provided for in the Water Code is believed in its essentials adequate for the purpose of adjudicating the less extensive ground water basins, with a few exceptions. Under general rules of practice, a notice of action, or *lis pendens* as it is called, can be filed in any suit involving the title to real property and then recorded in the office of the appropriate county recorder. Thereafter a buyer of the property during the pendency of the suit is charged with notice of the suit. In water cases frequently the large number of parties renders resort to the existing procedure infeasible. A practical *lis pendens* procedure should be supplied.

There should also be added a provision expressly sanctioning orders by the court for trial distribution on motion of the parties or of the referee. Such a provision would be of great practical utility. By this means would be afforded the acid test of trial of a proposed solution of water problems under actual field conditions. Inadequacies would thereby be brought to light and could be rectified.

Statutory Adjudication Procedure

There is in the Water Code another procedure designed to attain a similar objective to that of the court reference procedure—an adjudication of rights to the use of water. This further procedure, for purposes of distinguishing it from the court reference procedure, is commonly referred to as the "statutory adjudication procedure." Jurisdiction is acquired by publication and service of notices by mail. It is designed for extensive adjudications. The statutory authority, however, expressly excludes rights to the use of ground water unless consisting of subterranean streams flowing in known and definite channels. The procedure is initiated by petition to the State Engineer by one or more claimants to the water of a stream system, requesting determination of the rights thereto. If upon investigation it is found that the facts and conditions are such that the public interest and necessity will be served by a determination of the water rights involved, the petition is granted and the proceeding is initiated. The procedure was adapted from the Oregon Law and follows it closely. The Oregon procedure has been extensively litigated and in one case was carried to the Supreme Court of the United States, resulting in an opinion considered classic on the subject. That opinion thoroughly explored the procedure and held it to be in all respects valid, and commended it highly for use in extensive adjudications.

In the California procedure, notice of the pendency of the proceeding is given by publication. Claims of the respective parties are registered in what are referred to as "proofs of claims," and each right is in issue as against each and every other right. Each party may contest any other right. The proofs of claims and the statements of contestants constitute the pleadings. The facts are then found by the State Engineer, after hearings on the contests, ending in an "order of determination" which is then filed with the superior court of the county, or one of the counties, within which all or part of the stream system is located. Thereupon the order is subject to exceptions and hearing thereon before the court, resulting in a decree of the court which is subject to appeal as in other cases. This procedure has been upheld as valid in two decisions in California courts, one of which was by the Supreme Court of California, the

other by a district court of appeal. A substantial number of adjudications have been conducted pursuant to this procedure, and it has been found by experience to be essentially workable and valuable for extensive adjudications, but a number of defects have been noted, the broadest of which is the inability to include rights to percolating ground water sources. To make the procedure entirely satisfactory, it would be necessary to revise it to remedy all the defects which have been noted.

Recommendations

It is believed that both procedures can be materially improved, but legislation to remedy major defects only are herein recommended, with particular attention to such as are considered necessary to improve and perfect procedures for facilitating adjudication of ground water rights. In addition, as has been noted, legislation is required to authorize the exercise of powers essential to carry into effect the California Water Plan presently in process of formulation.

The recommended items of legislation may be listed as follows:

1. A constitutional amendment authorizing: (a) the planned utilization of ground water basins for carryover storage, and (b) adjustment of conflicts with existing rights either by delivery of water or by cash compensation.

2. The requirement of permits and licenses for the appropriation of ground water authorizing extensive drawdown of ground water levels in time of need.

3. Control and supervision of recharge of depleted ground water basins.

4. Provision for recordation of records of ground water use which upon verification shall be admissible in evidence in an adjudication of the rights involved, with prima facie effect.

5. Revision of existing procedures for the adjudication of water rights, both surface and underground. As has been stated, the court reference procedure can, and it is believed should, be materially improved in several respects. The improvements recommended in both procedures are:

a. A practical *lis pendens* procedure should be supplied. This should apply to both procedures.

b. The trial court should be authorized to refer any case involving the determination of water rights, surface or underground, at any time after filing of the complaint, to the State Engineer, with direction to follow either the statutory adjudication procedure or the court reference procedure. This would supply a most desirable flexibility.

c. Authorize the trial court to impose, from time to time, trial distribution schedules. This also should apply to both procedures.

d. Authorize the State Engineer to investigate and report upon all rights to the use of water, including ground water rights. This is necessary only in the statutory adjudication procedure.

e. Provision should be added to the statutory adjudication procedure to the effect that initiation of a proceeding tolls the statute of limitations, and that an action to adjudicate the rights, in whole or in part, involved in any such proceeding, filed during the pendency thereof, on motion of the State Engineer, shall be abated.

f. Authorize the trial court to impose a physical solution either as recommended by the referee or as suggested by the court or the parties, and

to enter any other order as the interests of justice may require. This should apply to both procedures.

g. In entering its judgment the trial court should retain broad jurisdiction in accordance with the principles approved by the Supreme Court of California. This also should apply to both procedures.

Frequently, in the more extensive adjudications, there are included a large number of users who collectively utilize, or claim the right to utilize, an insignificant percentage of the total available supply. They are, of course, proper parties to the adjudication, but certainly they are not necessary parties in a practical sense. Based on our experience it is believed that substantial expense and delay can be obviated by their elimination as parties to the adjudication without adversely affecting the enforceability of the decree when entered. This expedient can be resorted to, when appropriate, under existing law, without necessity of supplying new legislation.

Finally, a program should be adopted for continuing investigation of the ground water areas of the state, particularly those determined to be required for carryover storage in operation of the California Water Plan, supported by adequate appropriations. By this means, as and when it were to become necessary to adjudicate rights to the use of these ground water basins, to the extent the necessary data were available, expense and delay of adjudication thereof would be minimized.

The legislation herein recommended would enable the following:

1. The planned utilization, adequately supervised, of ground water basins, so as to afford the required carryover storage to make effective the California Water Plan, affording required insurance against deficiencies in water supplies for beneficial use, including future periods of inadequate precipitation and runoff, with adequate safeguards to existing rights.

2. Affording full recognition to the interrelationship between surface and ground water sources by providing for: (a) state protection and supervision of all rights to the appropriation and use of water, whether surface or underground; and (b) efficient procedures for adjudication of all rights to the use of water of whatsoever nature, at minimum expense and delay.

It is recognized that the foregoing does not supply the answers to all existing ground water problems within the state from the legal standpoint, and that doubtless additional legislation will be required. However, it is believed that these recommendations merit careful consideration in order to implement vitally necessary statewide plans for the conservation, utilization, and protection of our water resources.

California Ground Water Replenishment Bill

R. W. Chase

A paper presented on Oct. 29, 1954, at the California Section Meeting, Long Beach, Calif., by R. W. Chase, Atty., Chase, Rotchford, Downen & Drukker, Los Angeles.

THIS paper discusses a bill (Assembly Bill 2699), now pending in the state legislature, which is intended to provide the machinery for the creation of districts or zones to implement the replenishing of depleted underground basins through the importation and spreading or injecting of supplemental waters. For reasons to be explained, the bill has been proposed as an amendment to the Metropolitan Water District Act, under which the Metropolitan Water Dist. of Southern California was established.

Since the bill was originally drafted, a great many suggestions and changes have been offered, some of which are still under consideration. The present paper deals with the principle features of the bill, the merits of a number of the points at issue, the underlying concepts, and the scope of the problems involved, particularly those affecting Southern California.

Aside from questions of constitutionality inherent in formulating any legislation, the problems of providing for the replenishment of underground waters fall into five broad categories: [1] choice of the size, type, and manner of creation of the legal entity required to handle underground water replenishment; [2] determination of the nature and character of the administrative body, the manner of its appointment, and the length of its tenure; [3] determination of the quantity of supplemental water to be purchased, imported, and spread or injected; [4] selection of the means of financing the enterprise; and [5] manner of enforcement of the law.

There are, of course, many other problems that cannot be so easily classified. Limits of powers must be fixed. Established rights must be evaluated. Solutions that may appear extremely simple and workable must be examined and tested. For instance, it has been suggested that an existing city or other political entity could import supplemental waters, store them underground, and later extract and sell them. This might work if no one else had any right to extract ground water in the area involved. Otherwise, if the entity importing the supplemental water wished to assert ownership after the water had been put underground, it would have to condemn the underground storage right under every lot and parcel overlying the basin.

Legal Entity

The boundaries of areas having a common ground water source often do

not coincide with city, county, or other political boundaries. The result is that either a new law providing for the creation of a novel form of political entity has to be passed or else legislation creating replenishment zones has to be grafted upon a law governing some existing organization which transcends county or other political lines. The organization of a separate political entity seems to be cumbersome and unduly expensive. Under present law, a metropolitan water district is about the only available existing political entity whose boundaries cross county lines. The Metropolitan Water District Act appears to be the most suitable vehicle for providing the means of creating a district to place imported waters underground.

There is another factor which favors an amendment of the Metropolitan Water District Act. Southern California is rapidly becoming urban in aspect. Its underground basins differ substantially from those in the San Joaquin Valley and other parts of the state. Many feel that the problem in Southern California is essentially dissimilar to that in the north, and that varying solutions must be found for varying problems. The difficulty of drafting a law to meet the approval of all water users throughout the state is apparent. Only one metropolitan water district has so far been formed under the act. An amendment of the act would, therefore, as a practical matter, be applicable only to Southern California, where that district exists, and should not be objectionable to areas having different water and economic problems. Although there has been some criticism of the use of the Metropolitan Water District Act in this manner, the general principle has so far been well received, on the whole.

Assembly Bill 2699 provides that a proceeding to form a replenishment district or zone may be initiated before the board of directors of a metropolitan water district by petition of at least 10 per cent of the water producers of the proposed zone or by petition of those who have produced at least 10 per cent of the ground water extracted therein during the preceding year. Provision is made for engineering surveys and reports on the ground water supply of the proposed zone, the need and feasibility of replenishment, the estimated annual quantity of imported water necessary, the estimated annual cost, and other data required for a proper determination of whether such a zone should be created. Hearings must be held before an officer who is a qualified registered engineer familiar with water problems. His findings and recommendations are submitted to the board of directors and reviewed by them at a public hearing. If they rule that the formation of the proposed replenishment district or zone would be in the best interests of the producers of ground water within the area and would benefit all persons relying directly or indirectly upon ground water supplies therein, the board of directors can then order the formation of the replenishment district or zone.

The Metropolitan Water Dist. of Southern California comprises substantially all of the basins in the coastal plain that are presently suffering from ground water depletion. Express authority is conferred upon the board, however, to include in the replenishment zone the entire area underlying a common ground water source, even if part of it is outside the metropolitan district.

As now drafted, the bill provides that, as an alternative to proceedings

initiated by petition, the board of directors of a metropolitan water district may itself initiate such proceedings. Several restrictions to this power are under consideration. The replenishment zones are created for the purpose of buying supplemental waters. Because a metropolitan water district would be the seller of the water to be spread or injected underground, some feel that it should not have the power to form a replenishment zone or district on its own motion, unless a substantial majority of the board finds that an emergency which requires such action exists. Another suggested restriction is a provision that, where an existing agency controls the land overlying an entire underground water basin and is presently engaged in replenishing the underground waters, the metropolitan water district would be without power to create a duplicate zone. For instance, the San Fernando Valley lies entirely within the city of Los Angeles, and the Orange County Coastal Plain lies entirely within the Orange County Water Dist. Both of these agencies have, in one way or another, been engaged in regulating the amount of underground water in the respective basins. It would not seem to be good sense to create a district or zone to duplicate their activities unless they were so inadequate as to create an emergency. In such an instance, it is proposed that the existence of an emergency must also be asserted by a substantial majority of the board of directors of the metropolitan district.

Governing Body

Once the replenishment district is formed, provision must be made for a body to govern it. The bill now provides that the board of directors of a metropolitan water district shall be the governing body of the replenishment district or zone formed by it. The theory is that replenishment districts resemble special improvement districts, which the law now permits to be created for lighting and other purposes; such districts are administered by the governing body of the city or county in which they are formed. Furthermore, it may be necessary for legal reasons that the board of directors of the metropolitan water district have the ultimate authority.

It has, however, been argued in hearings on the bill that, because the parent district will be in the position of a seller of supplemental waters, the actual administration of the replenishment district or zone (as well as the determination of the quantity of water that it should purchase and spread and the amounts to be charged or assessed) should be left in the hands of a separate local board. As a consequence, a rough draft of an amendment has been prepared to provide that, for each replenishment district or zone created under the authority of the act, the board of directors of the parent district must appoint a commission or local board of five men, each of whom must be a citizen and resident of the replenishment district.

Consideration is being given as to whether the member agencies in the metropolitan water district should have the right to nominate a panel from which such local commissioners should be appointed. The author believes that such an arrangement is unnecessary. In the normal course of its exercise of such an appointive power, the metropolitan district board would obtain the recommendations or nominations of existing political entities and might also seek suggestions from such nonpolitical bodies as the local chamber of com-

merce and other associations having an interest in public affairs within the replenishment district. Regardless of how the members of the local commission are appointed, if the proposed amendment is adopted, the subsequent administration of the district's affairs would be largely in their hands.

The bill provides for the registration and metering of all ground water producing facilities. It contains provisions for engineering studies to be made; for the holding of hearings by the governing board upon the report of the engineers and upon other evidence that any interested party may supply; for estimates to be made by the governing board on water production, supplemental-water needs, and costs. In short, the governing body has the power to seek all the necessary information, make the necessary factual determinations, and take the necessary action to procure the supplemental supply.

The governing board is also given the power to levy assessments to pay the expenses of the endeavor. Although these functions were originally vested in the parent district's board of directors, under the proposed amendment they would all be exercised by the local commission. For legal reasons, the actual levy of any assessment or tax may have to be made by the board of the parent district; if so, the power of that board to make a levy in excess of the amount determined upon by the local commissioners could be adequately restricted.

The appointment of a local commission as proposed would not give local control in the way that the creation of an autonomous political corporation with elected officials would. The use of a local commission would, however, substantially prevent a metropolitan water district from acting for a subordinate area in purchasing water from itself, and the arrangement gives the greatest degree of local control that seems possible if the Metropolitan Water District Act is to be retained as the vehicle for restoring underground waters.

Supplemental-Water Needs

To determine the quantity of supplemental water needed each year, provision is made in the bill for hearings before an officer who reports to the governing board his findings on accumulated and current annual overdraft, availability and cost of supplemental supplies, and all other relevant items. The governing board then holds a hearing and makes its own findings, based on this report and on any other evidence submitted. The board determines whether and in what quantity supplemental water should be purchased, and makes estimates of the entire expense and of the amount of ground water which will be extracted during the ensuing year. With this information, it is in a position to determine the assessment that will be required to raise the necessary funds.

Finances

The most controversial question is how the expense of purchasing, importing, spreading, and injecting water is to be met. The bill now provides that a replenishment assessment, based on estimates obtained as previously described, be levied on each acre-foot of ground water extracted during the ensuing year. This assessment is not a general tax, and it can be employed only for the acquisition and use of supplemental waters for replenishing ground water supplies and for the ex-

penses incident thereto. No provision is made for ad valorem taxes on property. There is a provision, however, that a metropolitan water district may elect to pay from its general funds some or all of the administrative and overhead costs of a replenishment zone. These general funds may come, in whole or in part, from ad valorem taxes levied in the metropolitan district.

In the author's opinion, an assessment on all ground waters produced has much to commend it as a method of paying the expenses incident to replenishment. It places the burden on those receiving the primary benefit. If the water is resold for domestic and industrial use, it can be expected that the charges would reflect the assessment, so that the burden would be spread over a wide base. Such an assessment, however, does not meet with universal approval. Many producers feel that others benefiting by their overdrafts should help bear the burden. Be that as it may, provision for current revenue from taxes or assessments must be made to meet the current charges for supplemental water. The situation does not lend itself to financing on the basis of "prosperity at the expense of posterity."

The basic arguments for shifting the cost burden to others are two in number: one states that, because the preservation of ground water supplies raises land values, some form of ad valorem property tax is in order; the second holds that the overdrafts are largely caused by newcomers to the area or by persons pumping in excess of their legal rights, and that, if a production assessment is made, it should be levied only against waters pumped in excess of a producer's adjudicated rights. The latter procedure would require basinwide adjudication of pumping rights and safe yields.

It has been suggested that each local replenishment district board should be empowered to determine what type of tax or assessment should be made. This may be an answer which will meet the varying conditions in different areas. It is questionable, however, whether ad valorem taxes can be levied for or by a replenishment zone of the type proposed in the bill under discussion.

Ad valorem taxation seems a fair method of paying for replenishment to restore any existing overdraft, because the community as a whole has received the benefit of the water produced. For future overdrafts, however, the burden should be on the water producers and users. There are many other factors besides water supply which affect land values. The author believes that ground water replenishment does not benefit all lands in proportion to their assessed value and that an ad valorem tax for current replenishments would create greater inequities than a water production tax.

The use of basinwide adjudication as a foundation for levying assessments should be avoided, if possible. It is costly and time consuming. It would greatly increase the difficulties of administration and collection of the assessment. Material benefits would accrue to some water producers without cost to them. An assessment on all water produced would not prevent producers who are injured by the excessive pumping of others from pursuing remedies now or hereafter available for their protection.

The essential difference between a general production assessment and an assessment against water pumped in excess of an adjudicated safe-yield

right is that, in the former instance, a small assessment is made against a large, easily computed volume; in the latter, a large assessment is levied against a small volume arrived at only after expensive and complex proceedings. In the long run, the producers would be required to pay about the same amount of money under either method.

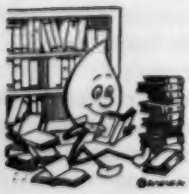
Enforcement

The enforcement provisions of the bill are relatively simple, but effective. Each operator of a water-producing facility is required to register it within a specified time. He must install a measuring device capable of recording his accumulated production, and he is required to file quarterly statements of his previous 3-month ground water production. At the time of filing, his assessment on that quantity is payable. Exceptions are provided for certain small producers.

For most of these requirements, failure to comply is made a misdemeanor punishable by a fine of up to $500 or by imprisonment up to 6 months, or both. In addition, the producer, in certain instances, is subject to payment of penalties and interest if he fails to file the quarterly statements or meet the assessment due. Even more drastic, any ground water producer who has failed to register his facility or pay his assessment may be enjoined from further pumping. Suit may also be instituted to collect the assessment. Means are provided for redetermining a producer's assessment in the event that he understates his production.

Conclusion

The proposed legislation does not purport to be a cure for all existing or future ground water supply problems. It does not, for example, concern itself with the prevention of contamination or restrictions against overpumping. It seeks merely to enable the establishment of replenishment districts or zones on a practicable, realistic basis. Thus, the bill is only one step—but an important one—in the program for meeting the ultimate water needs of the people of California.



Legal Liability of Municipalities and Officials

H. Winston Hathaway

A paper presented on Sep. 16, 1954, at the Michigan Section Meeting, Muskegon, Mich., by H. Winston Hathaway, Asst. City Attorney, Muskegon, Mich.

THE basic rules which govern official acts are substantially the same in every state. If water works officials or other municipal employees should act contrary to valid charter requirements, legislative acts, or state constitutions, they may subject themselves to personal liability for any resulting loss.

Public officials usually are held personally liable for negligence even in the performance of a ministerial act. Employees who commit a wrongful act or violate a duty are liable for any resulting damages. The general rule is that municipal officers while acting in good faith, within the scope of their authority and without negligence, are not personally liable to individuals damaged by the construction of public improvements (*1*).

There are exceptions to this rule, as there are to every general rule. In 1878 a village common council instructed the street commissioners to lower the grade of an unopened street preparatory to placing it in public use. Excavation caused the fence of the adjoining owner to collapse. The lady who owned the adjoining land was quite indignant and filed suit against the street commissioners. She testified that the work crews not only caused the fence to cave in, but, no doubt inadvertently, hauled it away. The supreme court of Michigan sustained a judgment against the two street commissioners for damages. A quotation from the opinion (*2*) follows:

> It is thus shown by the evidence that the injury the plaintiff received at the hands of the defendants was not only the direct and necessary result of their acts, but it was also immediate. They did not enter upon her premises, but they undermined them by an excavation, so that they necessarily fell with the removal of the support. They fell at once, as the result of acts intentionally done, and not subsequently as a consequence of negligent conduct.

This case is interesting because the court did not require proof of negligence on the part of the street commissioners. The act of undermining the fence was intentional, and it was wrong to deprive the adjoining land of lateral support. Therefore, these two city employees, acting under instructions of the common council, were held personally liable for damages.

Authorization Requirement

In *Larnard* v. *Briscoe* (*3*), decided by the Michigan supreme court in 1886, the Detroit Board of Public Works, without first obtaining the approval of the common council, hired contractors who lowered the grade of a street 6 ft preparatory to paving. Of course, the adjoining lot was left as it was, 6 ft above street level. The

owner of the lot sued the board and the contractors for his damages, and he recovered. The theory was not that the defendants were negligent, but that the excavation was unauthorized. The liability of the Board of Public Works and the contractors did not result from any negligence in the performance of the work but from the failure to obtain the permission of the common council before work was commenced. Years before this case was decided, the same court had held that an action would not lie against a city for changing the grade of a street (*4*).

Trespass

In *Hempfling* v. *Burr* (*5*), the court said: "Upon principle it would seem that a public officer should be held personally liable for a trespass committed by him or under his direction, even though he is acting in his official capacity." Accordingly, when a drain commissioner mistakenly constructed a drain across land without first obtaining a right-of-way agreement, he personally was held liable for the resulting damage (*6*).

Such cases serve as a warning that water works employees cannot, in the course of necessary duties, go upon or interfere with land belonging to others, no matter how innocently this is done, without becoming personally liable for any resulting damages.

Assumption of Liability

Another interesting situation arises when city employees supervise excavations being made by a private contractor in a public street. The contractor undoubtedly has signed a contract providing that, in the performance of the work, he will erect and maintain suitable barricades. The city employee can tell the contractor *where* to erect the barricades, but as soon as he attempts to tell the contractor *how* to do it, he becomes personally responsible for any defect in their construction which leads to injury to others (*7*). The theory upon which this liability is predicated is that, by issuing instructions, the city employee has contributed to the failure to barricade the excavation properly. Of course, there would be no liability on the part of the city employee and the contractor if they did exercise reasonable care to prevent injuries to others. Cities are liable only by statute for negligence in making street improvements. There is such a statute, chapter 22, General Highway Law, in Michigan.

City Immunity

Usually cities are immune from liability for injuries negligently inflicted on others because the city is engaged in the performance of a governmental function. The supreme court of Michigan, however, ordinarily will not extend such immunity to negligent acts by cities in the operation of water works. The court has said (*8*):

> Although a city may, in the construction, operation, and maintenance of a water works system, be acting, under certain factual circumstances, in a governmental capacity, as a general proposition the weight of authority is to the effect that in engaging in such an enterprise the city acts in a proprietary or private capacity.

The test of a city's liability for negligence in the operation of a department is whether there is any profit, even incidental, from that department to the city (*9*). If there is, the operation is private rather than public, and the city has no immunity from liability

for its negligence. It can be seen that at times it does become dangerous to operate a water department at a profit.

The governmental-function rule would apply, for example, if a person enters a police station for the purpose of reporting an accident and injures himself solely by reason of some defect in the floor. The police department is maintained as a governmental function, and the city could not be held liable for its negligence in permitting that defect. Yet, if the defect in the floor existed in the offices of the water department (from the operation of which the city derived some kind of profit, directly or indirectly), then the city would be liable for the negligence of that department in permitting the defect in its floor to cause injury to some unsuspecting citizen.

Another example occurred at Grand Rapids, Mich., where a boy drowned while swimming in a pool constructed and operated by the city. The parents sued, claiming negligence by the city, but recovery was denied (*10*). If the city had charged an admission fee which more than paid the cost of operating the pool, the recovery in all probability would have been allowed. The element of profit would have turned the operation of the pool into a private, or proprietary, function, instead of a governmental one.

Responsibility for Employees

As a practical matter, it may be important to municipal employees that the city would also be liable for their negligence. In that event, the claimant might decide to sue only the city, as frequently happens. If the suit is filed against both the city and the employee, it is probable that the city will pay the damages.

There is a Michigan statute barring the use by cities of the defense of governmental function in actions brought against them for the negligent operation of motor vehicles (*11*). The same act permits cities to pay the premiums on automobile insurance policies which will protect any officer, agent, or employee, as well as the city, from liability in the operation of a city-owned car. It might be a good idea to make certain all cities' policies are written to protect everyone concerned.

There is no liability for mistakes made in exercising judicial or quasi-judicial discretion granted by law. It has been held that a township board acts judicially in auditing claims against the township, and its members are not liable individually for erroneous allowances (*12*).

There can usually be no remedy for a wrong if the remedy would involve the review of a lawfully vested discretion. There must generally be an excess of jurisdiction or an act outside of the discretion vested in the city employee before he can become liable personally for any resulting damage (*13–15*).

Municipal officials must not intentionally hire people they know to be incompetent, or to act maliciously, unlawfully, or in bad faith. If officials do so, however, suit can be brought and recovery had only by a person who can show direct injury to himself resulting from the improper action.

If the water works manager orders the connection to the home of a consumer shut off because the bill was not paid, no liability will result (*16*). But should the citizen come into the office and make himself obnoxious, the official must not take it upon himself to eject

the man instead of calling a policeman. That would be an improper assumption of authority. Although the city may not be liable for the bumps, bruises, and abrasions the citizen may suffer, the official will be.

Conclusion

Water works officials should not exceed the scope of their authority. If they do so, they may be held personally liable for any injuries resulting. While employees act in good faith within the limits of authorization, and without negligence, they are not personally liable to injured individuals. Entry on private property without the owner's permission will result in liability for any resulting damage, proof of negligence or bad faith not being essential to a recovery.

In many cases, municipalities may be held liable for injuries caused by negligent employees. Governmental agencies which are not operated at a profit generally may not be held liable for injuries arising from negligence. Such immunity, however, may have been removed by statute.

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Split-Treatment Method of Water Softening

Arnold K. Cherry

A paper presented on Oct. 15, 1954, at the Iowa Section Meeting, Cedar Rapids, Iowa, by Arnold K. Cherry, Plant Supt., Water Works, Cedar Rapids, Iowa.

A SPLIT-TREATMENT method of lime softening has been used at Cedar Rapids, Iowa, except for a few days, since April 1953. About 30 per cent of the water is clarified with alum and then mixed with softened water to give the desired pH and alkalinity in the finished water without the use of carbon dioxide. The split treatment has permitted simplification of controls, effected more uniform results, and presented savings in operating costs.

The cost of this treatment has been about $1,000 a month less than that of conventional softening methods. During the 1-year period ending Aug. 31, 1954, $7,255 less lime was used than in an average year with the former treatment. Fuel oil savings amounted to about $2,550 for the year 1953–54, averaging $210 per month. During the winter there is no saving on fuel, as the boilers have to be operated for heating the building. Another saving, about $2,500, was made in reduction of power required to operate the compressor used to pump carbon dioxide from the boiler room to the basins. The compressor was occasionally used to pump air into the recarbonation chambers to prevent ice formation during very cold days.

Total savings for the year on these three items amounted to about $12,300. In addition, the expenditure for soda ash was reduced about $1,890, which brought the total saved to more than $14,000. Still another economy, which cannot be evaluated in money, was on maintenance of compressors, scrubbers, and driers. New recarbonation equipment would have had to be purchased if recarbonation had been continued.

Control Simplicity

The simplicity of control connected with split treatment appeals to the operators. When carbon dioxide was used, it was controlled by adjustments in three places, while recarbonation was carried on in three basins. With only one pipeline from the compressor, an adjustment on one basin meant a change in all three. These adjustments were all guesswork, and it was not unusual to have to make them every 2 hr or oftener. With split treatment, pH is controlled by regulating the proportion of water being clarified. This is done with a 30-in. gate valve, and adjustment is rarely required. It is possible to operate for days at a time without adjustment.

The water quality has been very uniform, and, with the aid of return sludge, it has been possible to keep alkalinity below 40 ppm even in the coldest weather. The averages for the 1953–54 period were as follows:

Alkalinity	34	ppm
pH	9.65	
Magnesium (as Mg)	8.0	ppm
Calcium (as Ca)	21.5	ppm
Total hardness (as $CaCO_3$)	87.5	ppm

Complaints by consumers about rusty water totaled only 28 that year. None was due to the new softening method. Before the split treatment was adopted, there were periods during the summer when the finished-water alkalinities dropped to 20–25 ppm, resulting in water certain to be corrosive. It was in an effort to correct this condition that the first attempt at split treatment was made. At the time there were only two mixers and clarifiers. A valve was opened to introduce some raw river water into the second mixing basin. This did not prove too successful, because of high turbidities and algae counts. There was insufficient time for proper clarification before filtration, and the pH was in an unsatisfactory range.

Mixers and Clarifiers

Additional basins and filters were constructed in 1950 and 1951, plant expansion was completed, and all possibilities for split treatment were explored. Figure 1 is a view of the improved plant. Several methods were tried before the present one was adopted. There are now four sets of mixers and clarifiers (Fig. 2). The first two sets must be operated in parallel, but the final two may be operated either in parallel or in series. One of the sets of primary basins was set up for softening, while the other was used for clarification only. Operating the last two sets of basins in series worked fine when pumpage was 8 mgd or less, but when it exceeded this figure, the losses in head through the return bypass flume and rapid mixers raised the water elevation 1 ft or more over the weir in the third clarifier, while water was at weir level in the final clarifier.

The high water level threatened to float out the oil in the clarifier mechanism. To relieve this, a plate was partially opened, allowing some of the clarifier water to flow directly into the final set of basins. This unbalanced the latter chemically and made control more difficult. Another method used to keep basin elevations at a permissible level was to send some of the third-clarified water directly to the filters. Carrying the water level high over the weirs in the center-feed clarifiers reduced the efficiency of the basins considerably because of short-circuiting. It would have been impractical to operate this way during the winter, owing to ice formation. The rapid flow over the weirs is depended upon to prevent solid, wall-to-wall freezing of the basins.

The next major improvement in the treatment was utilization of a flume designed to introduce raw water to either of the final mixers. This allowed all of the water from the primary clarifiers to pass through one small recarbonation chamber, thus getting a mix. The water was then divided nearly evenly and flowed parallel through the final mixers and clarifiers. This method has been successful with pumpages up to 16 mgd. With a few changes in flume construction, reducing losses through the rapid mixers, it should be possible to operate at higher pumpages without raising primary clarification elevations too high.

Return Sludge

The use of return sludge solved the problem of high alkalinities in the fin-

ished water during winter, when softening reactions are slow. Old records show tap alkalinities as high as 60–80 ppm. The introduction of double recarbonation made lower alkalinities possible, but until return sludge was is only one sludge pump. It is necessary, therefore, to pump from each basin alternately for 2-hr periods. If the quantity of sludge in these clarifiers is insufficient to bring down the alkalinity to the desired point, or if the

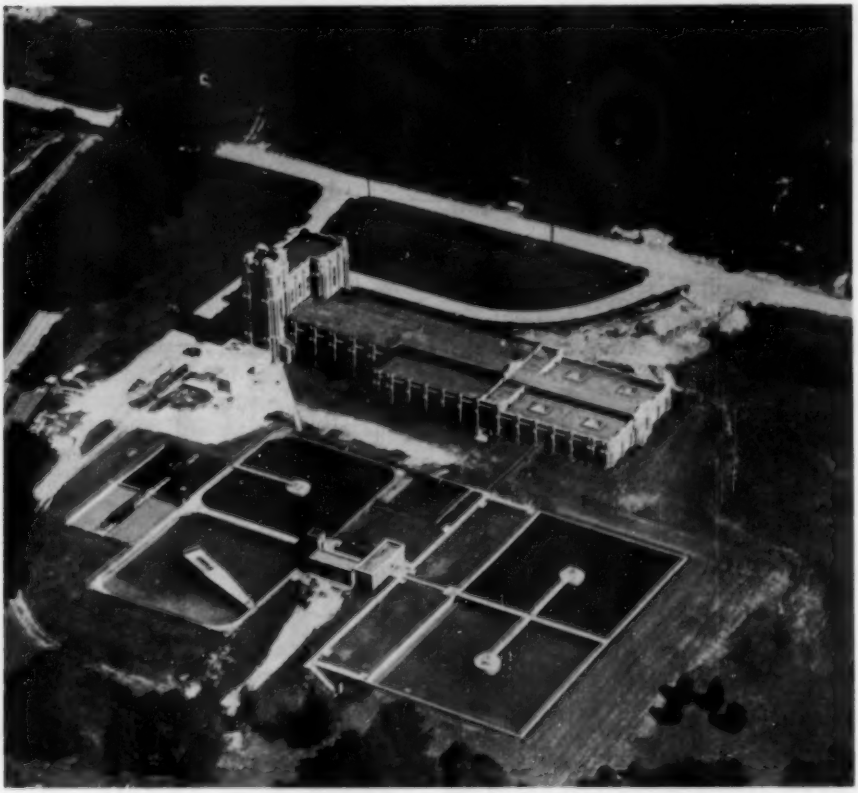


Fig. 1. Water Works at Cedar Rapids, Iowa

Split-treatment water softening has been successfully carried out at this plant.

used, averages below 40 ppm during the winter months were impossible.

At present sludge is being returned from the two final clarifiers into the rapid mixers in the middle of the process. These basins are each equipped with underwater clarifiers, but there water needs more sludge for stabilization (as shown by an alkalinity drop through the filters), additional sludge is introduced from the primary softening clarifier by means of another pump. When sludge concentration gets too great, some is sent to the sewer.

A reduction in total hardness, for which the return sludge is largely responsible, is the reason a saving in soda ash was possible. To keep the total hardness within the desired range, much soda ash had been used with the previous method of water softening. More coagulant might be supposed necessary with the new treatment than with straight softening and recarbonation. The alum dosage, however, averaged 24 ppm for the year 1953–54, nearly 9 ppm less than the average during the period 1948–52. The turbidity average for the year 1953–54 was only 83 ppm, against a 111-ppm average for the 5-year period. For normal turbidities, 17 ppm or slightly less is used on the softening side; 34 ppm or slightly more is used on the clarification side.

The lower turbidities contributed to the growth of a higher algae concentration than was ever experienced be-

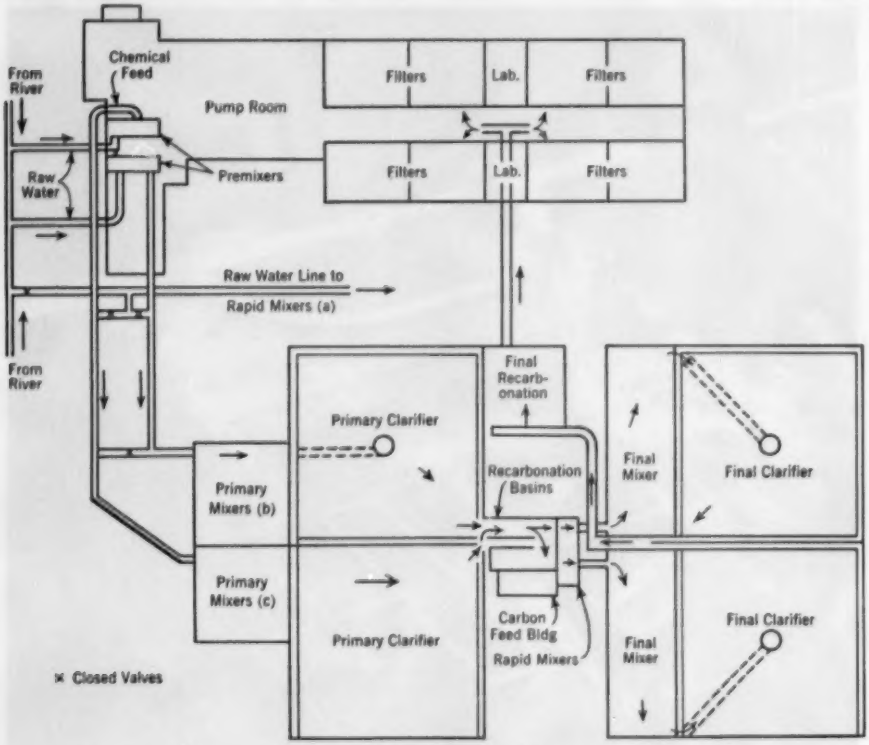


Fig. 2. Treatment Plant Layout

Key: (a) *not in use;* (b) *softening;* (c) *clarification only. Water from the primary clarifiers passes through a single small recarbonation chamber before separating into two parallel flows through the rapid mixers, final mixers, and clarifiers. Three of the clarifiers are center fed, and one is weir fed.*

fore, causing a higher threshold odor. The odor average was 65 per cent greater than the 5-year period average. More carbon was needed—particularly in the middle of the process—requiring more secondary coagulant; 6.5 ppm ferric sulfate was used, compared with 5.6 ppm for the 5-year period. (Ferric sulfate has been used as a secondary coagulant because it has proved more efficient than alum at a pH of 10.0 or slightly less.) The average settled-water turbidity on the filters in the year 1953–54 was 1.5 ppm, and the percentage of wash water used was about 1.75.

Taste and Odor

Probably more carbon is required for taste and odor removal with this treatment than would be necessary if all the water were softened. Odor removal through the primary clarifiers is usually proportional to algae removal. With a pH of about 11.0 in the softening basin, more than 97 per cent of the algae are removed by the time the water leaves the clarifier. In contrast, there is only about 75 per cent removal at the effluent end of the clarification basin. During the year ending Aug. 31, 1954, 7.3 ppm carbon was used, compared with 5.5 ppm in 1952. The 5-year average (1948–52) was only 3.35 ppm. The 5-year threshold average, however, was only 17.4 ppm, against 28.8 ppm for 1953–54. In the latter year it was necessary to apply carbon almost continuously during the winter months because of intensive algae odors.

When a satisfactory ground water supply is available, the mixing of the softened water with ground water would be ideal. This supply would have to be available in quantities equal to at least 25 per cent of the maximum daily consumption. It would greatly increase the practical maximum rate in the present basins with a split treatment. Then it would be possible to use both primary mixers and clarifiers for softening in parallel. Future research on the availability of ground water in the vicinity of the plant would be desirable.

It should be mentioned that sodium hexametaphosphate is applied, principally to prevent excessive calcium carbonate deposits in the cold-water lines close to the plant. About 0.5–0.75 ppm is used, and this frequently is divided between two points of application, the filter tops and the clear well. The purpose of applying the phosphate at the top of the filters is to prevent a reduction of carbonates through them. By applying sufficient sludge in the middle of the process, it is possible to stabilize the water so that there is no appreciable drop in alkalinity through the filters. The carbonate reduction, however, is sometimes too great, and the alkalinity of the settled water drops below 30 ppm. In that case, the returned sludge is decreased to raise the alkalinity and the phosphate is depended upon to prevent an alkalinity drop through the filters. By avoiding the use of the filters as a means of softening the water, it has been possible to use the same sand in the old filters for 19 years.

The present treatment has proved to be a simple, economical method of softening water without sacrificing quality. Furthermore, the method will probably be improved in the future.

Consumer Service Requirements

Emil S. Mamrelli

A paper presented on Oct. 29, 1954, at the California Section Meeting, Long Beach, Calif., by Emil S. Mamrelli, Distr. Design Engr., Dept. of Water & Power, Los Angeles.

DOMESTIC service connections and private supply lines are very important parts of a water distribution system. With the exception of water bills, service connections provide the most intimate contact that consumers have with water companies. A water utility is judged, and its reputation is largely established, by the adequacy of its service connections. A great deal of time is taken in designing supply and distribution systems to provide communities with safe, dependable, and adequate water supplies. Service connections and house supply systems must receive the same care in design if maximum benefit from supply and distribution systems is to be derived by consumers.

Continued rise in standards of living is accompanied not only by increased per capita water use, but also by a new concept of water supply adequacy. Water-using household appliances are rapidly increasing in popularity. The automatic nature of these appliances enables consumers to operate a greater number of fixtures simultaneously, thereby increasing peak demands on services and house supply systems. Cognizance of these changing conditions and increased allowances for anticipated future use must be taken in service and plumbing design.

Present methods of sizing services and plumbing in Los Angeles, along with current service problems, anticipated future domestic consumption, and investigation and evaluation of water service problems are discussed in this paper.

Plumbing Code

In Los Angeles, services, meters, and house supply systems are sized in accordance with the plumbing code incorporated as an article of the Los Angeles municipal code. The provisions for determining the size of service, meter, and house supply line are based, in general, on two National Bureau of Standards (NBS) reports (*1, 2*).

These publications present a method of determining probable or design flows on a fixture-unit basis. Each water-using fixture is assigned a certain number of "fixture units." The total number of fixture units in a dwelling or building is used to determine theoretical flow. A probability curve is charted which has flow in gallons per minute as the ordinate and fixture units as the abscissa.

Allowable pressure loss per foot is established by considering minimum pressure in the distribution main, differences in elevation, loss of pressure in the meter, distance from the street main to the farthest fixture, and desired residual pressure. The NBS publications recommend minimum residual pressures of 8 and 15 psi, respectively, for flush tank and flush

valve installations. The size of water service, house supply line, and branch pipe are then determined, using the allowable pressure loss per foot and the maximum expected demand for the length of pipe under consideration. To facilitate handling large numbers of service requests, tables based on the procedure described have been prepared and included in the plumbing code. Services, meters, and other piping can be sized rapidly by reference to these tables.

The service design tables are limited in scope and cannot be used for some special or unusual service conditions. The plumbing code requires a mandatory design, based on the principles and procedures recommended in the two NBS reports, for those service conditions outside the scope of the design tables.

In Los Angeles, the sizing of all services, meters, and house supply lines is under the jurisdiction of the plumbing department. As a convenience to the customer and to the plumbing and water departments, however, a working agreement has been reached which permits the water department to size services and meters that are less than 2 in. in diameter. This enables most customers to make all arrangements for water service in one visit to the water department. The sizing of services 2 in. and larger is handled by the plumbing department.

Pressure and Flow Requirements

Because the water utility is the distributing agency, it is the first to become aware of changing consumer water requirements. Meter books, flow charts, and other records show the consumption growth trend. The urgency of the problem, however, is better indicated by the number of complaints about pressure which are received. In Los Angeles, pressure complaints have been increasing in recent years. As these complaints have originated in both old and new service areas, it has become necessary to re-evaluate consumer water service requirements.

A large number of pressure complaints result from the installation of additional fixtures—such as sprinkler systems, washing machines, and dishwashers—without enlarging the original plumbing system to provide for additional water demand. The average consumer who makes fixture additions to his plumbing system is unaware of hydraulic principles. This fact results in expense to the department, which must investigate the pressure complaints that follow, and to the consumer, who must correct the deficiency.

An easy solution to the problem is to design adequate service lines, meters, and house supply lines initially, by raising minimum size requirements. In most instances, house supply system capacities in excess of immediately expected demands would result. Extra system capacity would be available to supply additional appliances that are likely to be added in the future. This solution would minimize pressure complaints involving future service installations; deficiencies in existing services would be remedied whenever wear makes replacement necessary.

Flow and pressure requirements for some of the fixtures or appliances which are likely to be added to a plumbing system have been investigated. The most common lawn sprinkler system in Southern California is an underground or concealed installation using small, fixed sprinkler heads set flush with the lawn surface. These sprinkler heads, under operating pressures of 10–20 psi, have capacities of 1.5–3 gpm. The number of sprinkler

heads placed on a single or branch line varies widely but usually ranges from six to fifteen. Thus, flow demands on any one sprinkler line generally vary from 9 to 45 gpm, but are sometimes much more. The pressure required to deliver these quantities to the sprinkler heads with 10–20-psi residual is dependent on the length and size of pipe involved. As a general rule, at least 30 psi is required at the point of sprinkler line takeout from the house supply line. As sprinkler systems are commonly operated during peak demand periods, a minimum additional capacity of 9 gpm should be provided in services that have not previously included sprinkler systems. The validity of this proposed requirement is emphasized by a reliable estimate that 25 per cent of homes in Los Angeles County now have such systems. In future years a much higher percentage of sprinkler systems can be expected. A well designed lawn sprinkler system that operates properly is a definite convenience to a consumer. Also, higher incomes and low-cost plastic sprinkler sets that can easily be installed have placed such systems within the reach of most homeowners.

Individual flow requirements for automatic washing machines and dishwashers are not, in themselves, excessive. Washing machines require about 7 gpm during filling cycles, and dishwashers require 2–5 gpm. For proper operation of these appliances, the flow must be supplied at a constant rate. Appliance inlet valves are set at the time of installation to allow the proper flow at predetermined pressure. If this pressure is materially reduced, appliance filling time is lengthened and the timing sequence of the machine is disrupted. Many consumers are forced to schedule water use so that adequate pressure will be available for operation. As these appliances are coming into general use in Southern California, water quantities and pressures required by the devices cannot be ignored in service and plumbing design.

Widespread use of garbage disposal units adds only a small quantity to total system consumption. Disposal units may be operated satisfactorily with flows as small as 2 gpm. These devices are important considerations in service and plumbing design, however, as simultaneous use with other appliances requires greater service and plumbing capacity to meet maximum demands.

In the past, the use of flushometer valves in private homes has been limited. Because these valves are convenient and space saving, increased use in the future is inevitable. By using these valves as the controlling mechanism, most ordinary water closets can be adequately flushed with 4 gal of water. To accomplish this flushing, the water must be supplied to the valve in a very short length of time, approximately 10 sec. Thus, a flow of at least 24 gpm must always be available for this type of installation, because it is impossible to predict the time or frequency of operation.

Each of the appliances discussed so far has definite pressure and flow requirements for satisfactory operation. The amount of extra capacity which should be built into private house supply systems partly depends upon how much additional plumbing cost consumers can reasonably be expected to pay on original installations in order to obtain future savings and convenience. This question may not be resolved satisfactorily by the prospective customer, as he is concerned with keeping initial building costs to an absolute minimum. The water utility can be of real service to the consumer in ad-

vising him of the minimum size of service and meter he should have installed.

Usage Tests

Experience in investigating pressure complaints has shown that it is a prevalent consumer belief that any deficiency in water service is the result of reduced pressure in the water system distribution mains rather than a deficiency in private plumbing. This general belief has forced the Los Angeles water system to revise its service test methods. The new tests serve a dual purpose: [1] to determine the source and extent of pressure trouble; and [2] to collect data which will be useful in determining desirable service design standards, taking into consideration probable future demands and actual economy to the consumer.

The tests are conducted in the presence of the consumer, if possible, so that he can observe the methods and results. Pressure gages are situated so that pressure losses for the service line, meter, house supply line, and internal house plumbing can be determined quickly by subtracting the readings of adjacent gages. The tests have been very successful in improving public relations. The source of trouble is shown directly by the pressure gage readings, and the consumer can be properly advised of the most economical method of correcting his pressure trouble. There is no need to use hydraulic computations, which are more likely to confuse than satisfy the consumer.

The revised service tests now being conducted are relatively simple to perform, yet supply enough data to plot the pressure gradient for the various reaches of pipe being used in the domestic supply system. The total flow to the system is obtained, but flow to the individual branches must be approximated or calculated using the total-flow information and the pressure gradient.

The equipment used in testing the plumbing of most private residences consists of four pressure gages calibrated in 1-psi increments, a stopwatch, and two short lengths of riser pipes with low head loss, one of which has been equipped with a blowoff valve. The riser pipes provide pressure gage outlets on each side of the meter.

Installation of the test equipment is accomplished by removing the water meter and its housing. The riser pipes are connected to the service and house supply line, so that the blowoff valve will be on the discharge side of the meter. The meter is then connected to the riser pipes above its original position. Next the pressure gages are installed, on each side of the meter and on hose bibs at the front and back of the house.

The test procedure is as follows: Water is turned on, and each of the four pressure gages is bled to discharge any existing air. Static readings of the four gages are taken, and any differences in readings due to elevation in terrain are noted on the data sheet shown in Fig. 1. This completes preliminary preparations for the tests. The following data are recorded on the data sheet for each test run: pressure readings of the four pressure gages, meter readings at the beginning and end of the test run, and the time of the test run. The service line and meter are first tested by opening the blowoff valve on the discharge side of the meter. Then the front-yard sprinkling system (or hose bib, if a sprinkler system is not available) is tested. Fixtures within the house are opened progressively, and readings are

Owner: _____
Address: _____
Los Angeles, Calif.

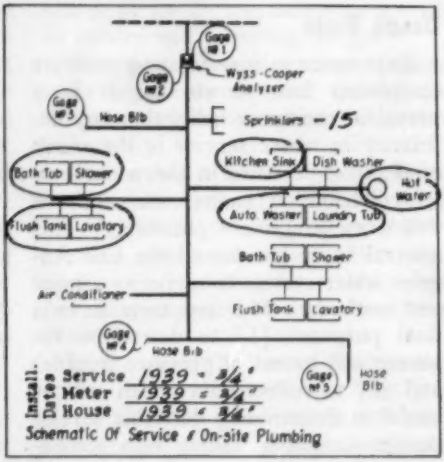
Water Sys. Elev. 426 Date: 10/6/54
Ground Elev. 385
Temperature — °F.

FIXTURE UNIT VALUES
from L.A. City Plumbing Code

Fixture	No.	Value	Total
Lavatory	1	1	1
Flush valve	—	6	
Flush tank	1	3	3
Bath tub or shower	2	2	4
Kitchen sink	1	2	2
Dishwasher	—	*	
Laundry tub	1	3	3
Automatic washer	1	3	3
Air conditioner	—	*	
3/8" Hose bib	—	1	
1/2" Hose bib	3	2	6
3/4" Hose bib	—	3	
Sprinkler Heads	15	1	15
		TOTAL =	37

*Not given in Code

Design flow on fixture unit basis - 23 gpm @ 8 psi residual



Schematic Of Service & On-site Plumbing

FLOW DATA TABLE

Street Main Pressure = 56 psi

		Test Run No. 1	2	3	4	5	6
Fixtures in Use	Lavatory						
	Flush valve						
	Flush tank						
	Bath tub or shower	1 Meter				1	
	Kitchen sink	1				1	
	Dishwasher						
	Laundry tub						
	Automatic washer				1		
	Air conditioner						
	Hose bibs	Garage					
	Sprinkler heads	1	8	15	15	15	
Data	Meter read end of run	3.0	3.0	3.0	3.0	3.0	
	Meter read beg. of run	0	0	0	0	0	
	Total volume, cu.ft.	3.0	3.0	3.0	3.0	3.0	
	Time of run, sec.	54.6	107.8	87.7	86.5	83.8	
	Flow in cu.ft./min.	3.30	1.67	2.05	2.08	2.15	
	Flow in gpm	24.6	12.5	15.3	15.5	16.1	
Pressure data in psi by pressure gage locations	1.	24.8	47.3	43.4	43.0	42.0	
	2.	9.6	13.1	37.8	36.9	35.8	
	3.		28.0	15.7	13.0	7.0	
	4.						
	5.		28.0	15.7	12.6	6.0	

Test Party: FELT
MARTINEZ
MEYER

Owner present Yes ~~No~~

Fig. 1. Test Data Sheet

The data are typical of test results where consumers complain of inadequate pressure. Four gages are situated so that pressure losses can be clearly shown to the consumer, who is usually present.

taken as each new load is imposed upon the system. New loads are added until all fixtures which might reasonably be in operation at one time are in use, or until the residual pressure has dropped below the minimum pressure allowed in the municipal code.

Results of Test

Results of a typical service test are shown on the data sheet in Fig. 1. A sprinkler system and an automatic washing machine have been added since the original plumbing installations. The original design flow for this system was 15 gpm, based on a total of 19 fixture units. The fifteen sprinkler heads and the automatic washing machine added 18 fixture units to the system, making the present total 37. On that basis, the Los Angeles code would have required a design flow of 23 gpm. Tests indicate this flow would have been insufficient, because the sprinkler system requires about 22.5 gpm, or 1.5 gpm per head, for proper operation.

The plumbing profile, location of test apparatus, and three pressure gradients depicting different conditions are shown in Fig. 2. The pressure gradient shown as a solid line was plotted from pressure data in test run No. 5 (Fig. 1). Observed flow during this run was 16.1 gpm, of which approximately 13.5 gpm was taken by the fifteen sprinkler heads in operation and 2.6 gpm by the bathtub and kitchen sink faucets. Flow to both the sprinklers and the house fixtures was very inadequate. The 16.1 gpm obtained during the test run was, for all practical purposes, the maximum flow of the system. This knowledge is valuable in determining the flow deficiency of the system.

The pressure gradient shown as a dotted line in Fig. 2 was calculated to illustrate the effect of replacing the existing ¾-in. service line, ¾-in. meter, and ¾-in. house supply line with a properly sized system—a 1-in. service line, 1-in. meter, and 1¼-in. house supply line. A total flow of 32 gpm was used in the calculations. This flow allows 22.5 gpm for the sprinkler system and 9.5 gpm for the kitchen sink and bathtub faucets. The pressure gradient shows that the required residual pressure is maintained at all points.

The pressure gradient shown as a broken line in Fig. 2 was calculated to illustrate the adequacy of the house supply system originally designed on the basis of 19 fixture units. The original design flow of 15 gpm was used, and all takeouts were assumed to be located in the vicinity of the bathroom. The resulting residual pressure was 9.1 psi, which exceeds the 8-psi minimum required by the plumbing code for this type of installation.

The test results and the pressure gradients vividly illustrate changing consumer service requirements. The test was made because of a pressure complaint by a consumer who apparently was unwilling to schedule his water use. The extent of the present deficiency in available flow and residual pressure can be observed by comparing the pressure gradient curves and the flow quantities. The curves also indicate the extent of deficiency that has resulted from the addition of the sprinkler system and washing machine to the original plumbing installation.

The deficiencies observed are quite typical of many consumer service problems experienced in areas that have moderate or average street main pressures, 50–60 psi. Some areas in Los Angeles are served by water pressures as low as 43 psi, a condition which aggravates consumer service

problems. Even in localities where pressures often exceed 75 psi, however, it is not uncommon to receive pressure complaints.

Conclusion

The investigations made and the test data compiled indicate the need for increasing service and meter size requirements. The data further indicate that 1-in. services and meters would adequately meet most consumer requirements. Therefore, to assure the consumer of reasonably adequate service, the Los Angeles Dept. of Water and Power is recommending 1-in. service connections as the minimum size for all new customers.

Water utilities that are experiencing an increase in complaints about lack of pressure may benefit by investigating and analyzing the economic advantage and consumer satisfaction accruing from the installation of adequately sized service lines and meters.

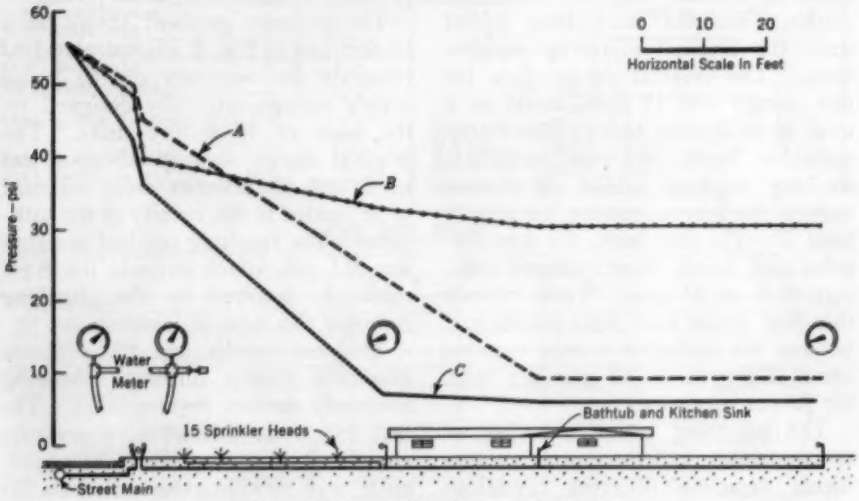


Fig. 2. Pressure Gradients at Test Site

A—Calculated pressure gradient for original design; ¾-in. service line, meter, and house supply line; total flow 15 gpm. B—calculated pressure gradient for 1-in. service line, 1¼-in. house supply line, and 1-in. meter; total flow 32 gpm. C—observed pressure gradient for existing ¾-in. service line, ¾-in. meter, and ¾-in. house supply line; total flow 16.1 gpm.

Acknowledgment

The author wishes to express his appreciation to G. A. Wyss, G. S. Cooper, L. W. Felt, C. A. Johnson, R. A. Child, L. L. Meyer, and other members of the water design and water distribution divisions of the Los Angeles Dept. of Water and Power who have assisted in the preparation of this article, perfected the test apparatus, and conducted the field tests.

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Consumer Complaints in the Southeast

John R. Bettis, Thomas King, O. M. Fuller, and L. E. Wallis

A paper originally presented as a panel discussion on Mar. 31, 1954, at the Southeastern Section Meeting, Greenville, S.C., by John R. Bettis, Mgr. & Engr., Comrs. of Public Works, Charleston, S.C.; Thomas King, Asst. Mgr., Water Works, Columbus, Ga.; O. M. Fuller, Supt., Board of Public Works, Gaffney, S. C.; and L. E. Wallis, Supt., Water & Light Dept., Elberton, Ga. The individual discussions were combined into one paper by John R. Bettis.

MANY of the so-called complaints by consumers are actually inquiries. In the Southeast section, the largest number of inquiries concerns high bills to those on metered service. If the manager listens patiently to the customer's argument that he could not have used so much water, the reason for the high bill will often be brought to light. For example, users who receive quarterly billings may forget that early in the period they used a lot of water for lawn sprinkling during a dry spell. Leaks and other abnormal heavy drains may also be an explanation.

It is helpful to have a meter reading record available to show the dissatisfied consumer. An explanation of how the meter works, using a cutaway model, will often convince him that the measurement is accurate.

High bills caused by leaks may be located by the consumer himself, if he is told how to use the test hand on the meter. Many plumbers are not familiar with this method and fail to stop wastage completely. Most customers with high bills are willing to look for leaks and have them repaired, if they understand the procedure.

Low Pressure

Another complaint frequently received by water works is that of low pressure. The following simple flow test can be made for each complaint: a hose is attached to the inlet meter coupling after the meter has been removed, and the time required to fill a pail of given size is noted. If it takes longer than the standard period for the size of service involved, corrective action should be taken at no cost to the consumer. If the standard is met, however, the consumer is notified that the trouble apparently is in his plumbing and should be rectified at his own cost.

Occasionally low-pressure complaints come from people whose water is obtained through a private main. Even though the water department has no responsibility, it still receives criticism. Strict utility control over private mains and their connections is a necessity.

Red Water

Complaints are often received about red water. This problem can be cleared up by proper use of metaphosphates. Incrustations on cast-iron

mains sometimes break loose after a high-velocity flow due to heavy hydrant usage. Allowing a small stream to flow from one or two hydrants in the affected area will eliminate the discoloration.

Shutoffs

Shutoffs for nonpayment have always been public relations problems. A tactful reminder notice sent out in a sealed envelope under first class mail will usually bring in 99 per cent of the accounts. It is necessary to treat all customers alike. In one Southeast city of about 75,000 population, the service to the water commission chairman was shut off because he disregarded his reminder notice. He was treated in the same way as other customers and he approved of the action. The general policy is that if service is discontinued, it is not restored until the bill, plus the penalty (usually $1.00), is paid. Frequently service is restored the same day the bill is paid.

False Readings

Water works officials often receive calls from customers who state that the meter reader did not, and could not, read the meter. They claim he just guessed at the consumption and wrote down some figures on the meter card. At Charleston, S.C., when a meter is covered or dirty or cannot be read for some other reason, the meter reader notes the cause of difficulty on the meter record card. Another man will then be sent to repair the meter and get the reading. This procedure relieves the meter reader of any temptation to guess at even one figure in the reading.

John L. Ford of the Ford Meter Box Co. tells of a customer who came into the office to complain that the meterman had not read the meter for several periods. When the superintendent asked the customer how he knew this, the explanation was that he had placed a silver dollar between the cover on the meter and the register glass, and the silver dollar was still on the meter. The superintendent called in the meter reader and asked him if he knew of any meter with a silver dollar in it. The latter immediately named the location and stated how long the coin had been there. The customer left hurriedly after which the superintendent told the meter reader to get on his bicycle, beat the customer to the meter, and remove the dollar.

Some of the practices of Southeast water departments in handling customer inquiries have been described. Many water works are beginning to realize that service, not merely water, is being sold to customers. Proper answers to customer inquiries are an important part of service.

Handling Consumer Complaints

Lawrence E. Martin

A paper presented on Sep. 28, 1954, at the Missouri Section Meeting, Jefferson City, Mo., by Lawrence E. Martin, Office Mgr., Missouri Water Co., Independence, Mo.

NO business operation runs smoothly all of the time. Eventually someone in the organization is bound to make a mistake which will be questioned by a consumer. Perhaps the customer will even become quite angry with the utility. Mistakes, misunderstandings, or negligence may cause him to tell the utility his feelings on the subject, and an unpleasant situation can easily arise.

Utility employees should realize that the customer did not invent an excuse for complaining. When talking with a complaining customer, the utility representative should strive to be tactful and refrain from letting personal feelings color his attitude. A cheery smile, if genuine, will disarm a dissatisfied consumer. The attitude presented must be one of willingness to help rectify the situation.

The water works representative should listen carefully to the complaint and remember that the customer may feel his grievance is unique as well as serious. Probably he has been thinking about it for some time. The listener should not interrupt the customer while he is describing his complaint. A utility representative is there to learn the causes of the complaint and to let the consumer unload his troubles.

Consumer Satisfaction

The consumer will often wish to see the head of the organization in order to obtain assurance that the complaint will be adequately dealt with. If the general manager is the person spoken to, the customer's ego will be gratified, a satisfaction he can mention to his friends.

Having heard the problem, the manager should be able to give a satisfactory answer. If the company has erred in handling the account or in rendering service, this fact should be admitted. Failure to do so will lead only to customer bitterness. Any mistakes must be promptly corrected. If the complaint is due to a misunderstanding, it should be cleared up by careful explanation. In addition, a digression to other matters of common interest will often create good will and allay anger on both sides. A genuine interest in the consumer and his problem will usually result in mutual satisfaction.

It is very helpful to let the customer aid in making the decision on rectification of his trouble. If an adjustment is needed, he might be asked just what he would do if he were the manager. By being taken into confidence, the consumer may very well agree to a settlement that is better for the utility than one the manager himself might propose.

A satisfied customer is the best advertisement a utility can have. Not only should a consumer's complaint be settled but he should be left in a friendly frame of mind toward the or-

ganization. The way in which customers are treated will eventually become known to all the people in the area. Although a water utility has a local monopoly, it must provide good service and fair treatment, or difficulties will result.

Summary

1. The customer's complaint is often at least partly the utility's fault.

2. A friendly attitude on the part of the utility representative is important to the maintenance of customer goodwill.

3. The representative should listen to the complaint attentively, without interrupting.

4. The customer should be allowed to play some part in reaching any decision for adjustment.

5. The customer should be left with a friendly feeling toward the company, for satisfied customers are an important asset.

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368	BELL, THOMAS, ROSENTHAL	Passage of Nuclear Debris Through Treatment Plants	Oct 54	14	25¢
369	HARRIS	Decade of Fluoridation	Oct 54	6	20¢
370	PANEL DISCUSSION	Fundamentals of Operation	Oct 54	15	25¢
371	PANEL DISCUSSION	Oil Pipeline Failures	Oct 54	11	25¢
372	PAUL	Valve Selection	Nov 54	20	30¢
373	CUNNINGHAM	Wood Stave Pipe	Nov 54	10	25¢
374	CHLORINE INSTITUTE	Stationary Chlorine Storage	Nov 54	12	25¢
375	WOLMAN	Providing Water Service	Jan 55	8	20¢
376	PANEL DISCUSSION	Ohio Fringe Area Service	Feb 55	9	25¢
377	JOSEPH, MAGUIRE	New-Utility Problems	Feb 55	6	20¢
378	BERGER, STEVENSON	Biological Warfare	Feb 55	10	25¢

FCDA Engineering Contributions Program

Arnold Nesheim

A paper presented on Oct. 29, 1954, at the Chesapeake Section Meeting, Baltimore, by Arnold Nesheim, Director, Emergency Restoration Div., Eng. Office, Technical Advisory Service, Federal Civil Defense Administration, Battle Creek, Mich.

THE objective of the Federal Civil Defense Administration (FCDA) engineering equipment contributions program is to assist states and their political subdivisions in establishing engineering resources required for civil defense activities and in making facilities available for training an adequate civil defense engineering force.

In 1951 and 1952 the FCDA conducted a nationwide sampling survey of engineering equipment resources. The survey showed that there was an adequate supply of heavy engineering equipment, such as earth-moving machinery and heavy construction equipment, for civil defense needs, but that certain other items were in short supply. The cost of total national requirements of these items in short supply has been estimated to be $69,000,000. In 1952 and 1953 the FCDA purchased $6,900,000 worth of these items with federal funds, including 450 miles of 8-in. light-weight steel pipe, 225 pumps (1,500-gpm capacity), 100 water filtration units, 45 mobile chlorinators, and 382 portable generators varying in size from 5 to 40 kw. This equipment, representing about 10 per cent of estimated total requirements, is now stored at 40 locations near 38 critical target cities.

For the fiscal years 1955 and 1956, however, the FCDA will participate in the procurement of engineering equipment and supplies only on a matching-fund basis. Under this program, the FCDA will assist states and municipalities by matching their expenditures for needed civil defense equipment and supplies with federal funds on a 50–50 basis. Requests for such assistance must be initiated at the state or local level.

All those types of items which have been found in short supply and which were stockpiled in 1952–53 will be eligible under this program. These comprise:

1. Light-weight steel pipe (8 in.) with grooved ends for victaulic type couplings, with related fittings such as tees, gate valves, and pipe caps.
2. Light-weight aluminum pipe (8 in.) with grooved joint ends for the same type of couplings.
3. Light-weight aluminum pipe (8 in.) with the shove-together type joint attached to the pipe.
4. Wheel-mounted centrifugal pump (1,500 gpm at 100 psi) with gasoline engine drive.
5. Skid-mounted portable purification unit (100 gpm), consisting of a pump and diatomaceous-earth filter; two 3,000-gal, collapsible, rubber-covered nylon storage tanks; and a 100-gpm gasoline engine–driven loading or transfer pump.
6. Trailer-mounted chlorinators with gasoline engine-driven pumps, having a capacity of 2 lb–300 lb per 24 hr.
7. Skid-mounted generators with gasoline engine drives, in 5-, 15-, 30-,

and 40-kw sizes. (Weights and costs of Items 1–7 are shown in Table 1.)

8. Items not listed may be eligible when adequately justified.

The water works equipment is designed to supplement existing water works facilities, and the generators are designed to provide emergency power for first-aid stations, mass care and assembly centers, usable existing hospitals, and other civil defense purposes.

In order to assist those states and municipalities which plan to participate in the matching-fund program, the FCDA has prepared a matching-fund manual (*1*), listing all items of equipment and supplies of the various services which may be eligible under the program. Chapter 10 of this manual covers engineering, items of engineering equipment and supplies eligible for contributions being listed in Annex 10-A. Sizes other than those listed in Annex 10-A may also be eligible for contributions, provided the need for the equipment and supplies can be properly justified in accordance with criteria for approval.

Federal contributions for engineering equipment and supplies of the types which have been described may be approved, subject to the following conditions:

1. Equipment or supplies for civil defense purposes must be adequately justified for local operational or training requirements, in accordance with the criteria.

2. Equipment and supplies must be made available in support of attacked areas, in accordance with: (a) intrastate mutual-aid and mobile-support plans, and (b) an interstate compact or, in lieu thereof, an agreement with the appropriate FCDA regional office for use of such equipment and supplies across state lines when requested by the office in an emergency.

3. Engineering equipment approved for organizational use on a standby or supplementary basis must be installed in a manner which would allow transfer to other locations if necessary.

4. Where engineering equipment is to be installed in an existing hospital, the hospital, to qualify, must be registered by the American Medical Assn. or the American Osteopathic Hospital Assn.

5. Contributions will not be approved when the engineering equipment is to be located within a "Class I vulnerable urban district" (defined below). Engineering equipment purchased on a matching-fund basis shall not be located within 10 miles of a Class I vulnerable urban district unless protective construction is provided to assure at least minimum operational capability of the facility.

6. Federal contributions will not be approved for the purchase of engineering equipment and supplies used in normal, day-to-day operations.

7. Federal contributions will not be approved for earth-moving equipment, air compressors; cranes; trailers; gas, water, electric, and telephone repair trucks; welding equipment; and other

TABLE 1

Weights and Costs of Eligible Items

Item*	Weight *lb*	Approx. Cost $
1. Steel pipe	200/20-ft section	1/ft
2. Aluminum pipe (grooved-end)	58/20-ft section	1.75/ft
3. Aluminum pipe (shove-together)	73/20-ft section	2.50/ft
4. Pump	6,000	3,500/unit
5. Filter unit:	4,500	5,100/unit
Filter		3,200
Pump		400
Tank (2)		750/each
6. Chlorinator	3,200	3,200
7. Generator:		
5 kw	900	1,200/unit
15 kw	1,800	3,000/unit
30 kw	2,500	3,000/unit
40 kw	3,500	3,500/unit

* For further description, see text.

items which have been found to be in adequate supply.

8. Federal contributions will be approved in amounts determined to be necessary to meet minimum emergency operating requirements only. This would not preclude participation to that extent in acquisitions involving greater financial outlays, if the local agency desires to finance the additional cost with its own funds. Examples of minimum emergency operating requirements are:

a. Water purification units: one unit may be approved for each planned 5,000-person casualty center, or 25,000-person evacuee center.

b. Pumping units: one 1,500-gpm water works pumping unit may be approved for each two 750-gpm fire pumpers (or fire pumpers of equal total capacity) required at the fire front.

A Class I vulnerable urban district is defined as a highly industrialized and densely populated section of an urban area that is enclosed by a line drawn through the centers of contiguous 4-mile diameter circles in each of which one or more of the following conditions apply:

1. Defense-supporting plants, each of which has 100 or more employees and which together have a combined employment of 16,000 workers.

2. Residential population of 200,000 persons.

3. Daytime population of 200,000 persons.

4. Major military installations or other installations of strategic importance.

Until such time as information concerning the boundaries of Class I vulnerable urban districts is disseminated to the field, the determination of whether or not a proposed site meets the requirements as to location with respect to the vulnerable urban district of a given city will be made by the appropriate regional office on the advice of the FCDA National Office prior to final approval of the application.

States are encouraged to submit consolidated statewide requests for engineering equipment and supplies wherever possible and feasible, so that advantage can be taken of the lower prices which large-scale buying affords. Application forms for matching funds (Form 233, "Project Application") are available at all state civil defense directors' offices.

The preceding statements have been limited to the procurement of engineering equipment and supplies for civil defense under the contributions program. There is another provision in the contributions program that is equally important: this pertains to the training of engineers for civil defense. Funds are available under the contributions program for training engineers, employees of the various municipal utilities, members of allied trades, and those in the construction industry, in civil defense in accordance with the provisions of Chapter 7 of the contributions manual (*1*).

All water works men are urged to take an active interest in preparing themselves for civil defense emergencies. Every community in the United States should be prepared to cope with disaster, wherever and whenever it strikes, with an adequate force of well trained and equipped engineers.

Reference

1. *Federal Contributions.* Manual 25-1, Federal Civil Defense Admin. Supt. of Documents, Washington 25, D.C. (Oct. 1954). Price $1.25.

Problems of Ground Subsidence

R. R. Shoemaker and T. J. Thorley

A paper presented on Oct. 27, 1954, at the California Section Meeting, Long Beach, Calif., by R. R. Shoemaker, Chief Harbor Engr., and T. J. Thorley, Sr. Harbor Engr., both from Long Beach, Calif.

SUBSIDENCE phenomena are known to geologists, foundation engineers and experts on soil mechanics. Technical literature has many discussions of surface phenomena that take place over a very long period of time. Man's concern with them has usually been academic, principally to further his knowledge of the processes of formation and change of the earth's surface or to furnish an explanation of geologic observations. The failure of roof supports in mining operations conducted relatively close to the surface of the ground is one of the commonest causes of subsidence. There are, of course, many others. The surface effects of various forms of subsidence may be quite marked and often present a serious problem. Small degrees of subsidence have frequently accompanied domestic water pumping, extensive production of ground water for irrigation, and drainage work in some areas. There has been little opportunity to chart subsidences because they are unobservable except through the use of precise surveying methods. In addition, there often are insufficient surface problems to justify engineering study. In most cases, knowledge of the subsidence probably does not exist.

In recent years, however, some of the larger subsurface operations have been located beneath extensive population developments, including high-value surface improvements. With increasing population along the shores of the continental United States and with the rapidly increasing demands upon these lands, aggravation of the problem may be expected in the future. Where a change in elevation of the earth's surface is near sea level or near the level of rivers and other bodies of water, and as additional instances of lowering artesian waters occur, the problem may often become quite acute within the economic lifespan of structures in the affected areas. Water works are no exception. Until results become quite apparent, few persons are likely to be concerned. The engineering professions should be alerted early if major trouble is to be prevented.

In the southern part of Los Angeles County small earth movements were observed and discussed long before any major subsidence occurred. These movements were generally on the order of a small fraction of a foot over a period of a decade or more. There was even some evidence of reversals of movement, between times of observation, and isolated cases of land rising were noted.

At the outset, studies on the subject were usually conducted purely as a matter of general interest among engineers and geologists.

Oil Land Subsidence

The discovery that the Wilmington oil field was partly beneath uplands

and partly beneath the publicly owned tidal and submerged lands imposed an unusual responsibility upon the harbor department of Long Beach. Tidelands had been granted by the state to the city, subject to a stipulation that the lands were to be used for harbor and allied purposes. Title to oil beneath the tidelands passed to the city, with the courts indicating that harbor uses should not be impeded by oil operations. From the very beginning of the tideland oil development, this port priority over oil development has been carefully observed.

Within 3 years after major development of the Wilmington oil field had commenced, it became obvious to the engineering staff responsible for the planning and designing of the port that, at some sites, there was a measurable downward trend in elevation that could not be accounted for by surface conditions. Following 1940 the annual rate of subsidence showed a marked tendency to increase and occasionally to fluctuate. The coincidence in area, amount, and timing of some of these surface changes with the rate of reduction of fluid pressures in the oil-, gas-, and water-producing zones of the sediments underlying the area strongly suggested a cause-and-effect relationship. This has since been the subject of intense study by a large number of investigators. They have given various opinions regarding the mechanics of the subsidence, the most effective means of studying and predicting it, and the feasibility of arresting it.

About 1944 it became evident that the rate of subsidence was accelerating toward a figure which might no longer permit surface construction projects to last out their normal economic life. In order to plan new work intelligently, as well as to handle maintenance, it was essential to seek all possible knowledge on the subject. Although the harbor department staff had its own views about the probable causes, it desired the completely unbiased and independent determinations of a board of outside experts. The US Navy, other public agencies, and large private property owners in the affected areas also began to feel the need for intensive study. As a result, a long series of such inquiries were initiated. These undoubtedly will be carried on for the duration of the phenomena.

To visualize the principal affected area as it existed prior to subsidence, picture an absolutely plane horizontal surface approximately 10 miles long and 5 miles wide, oval in shape, and positioned generally over the producing oil field. (This is an oversimplification, as there were varying elevations on the plane surface, including some ocean floor and harbor channels.) The plane surface subsided about 20 ft at the center of the oval and has dropped about 1 ft at the perimeter. Outward from this 1-ft isobase of subsidence, there is a very gradual decrease to zero over an undetermined distance. All surface points in the area have moved horizontally (generally toward the center of the oval) for distances which can usually be measured in feet. The differential movement is substantial in itself.

The oval of subsidence is deepening, elongating, and widening. It is also enlarging slightly more rapidly in the direction of most recent subsurface pressure drawdowns than in other directions, although this trend is slow. Upon this oval surface are improvements valued at well over a billion dollars, and in the more critical areas of the oval (those near the waterfront) the improvements are valued at more than $500,000,000.

Studies Undertaken

To study the causes of subsidence, a board of geologists was set up jointly by the Southern California Edison Co., the Craig Shipbuilding Co., and the Port of Long Beach. To obtain completely independent views, the US Navy at approximately the same time employed a private firm as consultants. The initial reports of the two groups were made with comparatively little knowledge of the thicknesses of oil-producing sands, the pressure drawdowns that might have occurred in those sands, and the probable extent of the oil field. Moreover, the investigators did not have full knowledge of the probable total number of oil zones which might ultimately be discovered and placed in production.

After comprehensive exploration of the possible causes of subsidence in the affected area, each of these groups of investigators concluded that the most important factor was the drawdown due to the production of gas, oil, and water. All of the investigators underestimated the maximum expected amount of subsidence, principally owing to insufficient data at the time of their studies. There was considerable disagreement on whether compaction was exclusively within the oil sands, or in the clays and shales, or in all three. After additional oil zones had been discovered and placed in production, each of the agencies prepared revised studies and again predicted subsidence based upon the data then known.

Possible minor sources of subsidence other than reduction of pressures in the oil zones included: withdrawals of water from confined aquifers; overloading of surface areas, thus consolidating sediments; vibrations of sediments from various causes; tectonic or crustal movements of the earth's surface; and lowering of the water table. In an area such as the one concerned, each of these causes—with the possible exception of tectonic action—can be relied upon to contribute to subsidence in some degree, though usually small.

As subsidence progressed to the advanced stage where its surface and subsurface effects became noticeable to the layman (see Fig. 1 and 2) and to the managements of the various interested organizations, restudies by the original investigators were ordered. Also, a very large committee, composed of management and engineers of the principal affected agencies, was formed. The engineering staffs of most of these groups were combined into a technical committee, with three main subcommittees: The oil well investigation subcommittee had the function of collecting all evidence relating to damaged or deranged wells in the

Fig. 1. Oil Well Tubing Deformation

Horizontal movement of the earth as a result of subsidence caused deformation of these pipes.

field, segregating and analyzing the data, and drawing conclusions if possible. The data collected by this committee proved later to have tremendous value in permitting analytical and statistically consistent approaches to some of the most important aspects of the problem. Another subcommittee had the function of predicting, as accurately as possible, the total amount of subsidence to be expected. The pressure maintenance subcommittee was to investigate the possibilities of gas injection and water flooding for obtaining secondary oil recovery and for accomplishing subsidence remedial work, as well as to recommend an experimental program, if advisable.

Fig. 2. Concrete Steps Cracked by Subsidence

Similar strains due to subsidence can destroy buildings and underground structures.

Committee Findings

These subcommittees reached some very important conclusions. Their general predictions on the amount of subsidence were reasonably consistent with the more elaborate studies prepared since that time. Another significant conclusion was that gas injection, alone, was impracticable as a means of arresting subsidence, but that intensive studies of the value of gas conservation, gas injection, and water injection for the purpose of increasing the ultimate recovery of oil should be made. The conclusion that pressure maintenance by water injection appeared feasible as a means of increasing ultimate oil recovery and possibly retarding subsidence was tempered strongly with the note that unitization (operation of a well field as a unit) was required to make it effective; that there was no record of retarding subsidence; and that laboratory and field studies should be undertaken before an actual program was initiated.

Although many studies have been conducted by Long Beach, by corporations, and by individuals, the joint efforts recommended by the committee, which might have resulted in early unitization and a secondary recovery program, were not then attainable. Unitization does not yet exist. Unitization, water flooding, properly coordinated production and repressuring programs, and a high degree of cooperation among all interested groups are the only means by which this problem can be lessened by subsurface work. In the meantime those responsible for surface installations must assume, upon the basis of past experience, that most, if not all, of the predicted surface effects will have to be offset. The remedial work obviously needed at the surface is a staggering burden which is being undertaken with dispatch.

There is subsidence of 1–3 ft entirely outside the limits of the oil field. If the basic problem is due to drawdown of fluid and gas pressures within the oil-bearing areas, one must con-

clude that the outside fringe subsidence either is caused by a drawdown in pressure of the waters at the edge of the field to less than the original hydrostatic pressure, or results from the fact that the overlying sediment is no longer supported within the oil zone, thus increasing the load on the elastic or plastic materials contiguous to the oil-bearing area. The drawdown in edge water pressure is the more logical cause. It takes little computation to illustrate that a pressure maintenance program must be gigantic in magnitude even to compare in effectiveness with the edge waters themselves over the tremendous areas of interfaces, between water-bearing and oil-bearing sands. Yet, in the authors' opinion, such a program must be carried out.

One of the manifestations of subsidence, and, incidentally, the factor which fixes mathematically the average depth of the origins of compaction, is the horizontal movement that has taken place both on the surface and beneath it. In its early stages, horizontal surface movement was evident to no one except surveyors. They invariably found that their results were inconsistent and that monuments within several thousand feet of the center of the bowl of subsidence tended to follow a constantly changing pattern of movement, though generally toward the center of the bowl.

The first major study of the horizontal movement came out of an intensive and careful routine survey of the triangulation network which had been established years before in the southern part of Los Angeles County. When horizontal movements of 2–4 ft were determined by this resurvey, they constituted the essential additional element necessary for a reasonably successful theoretical study of the subsidence phenomenon itself. It is obvious that fairly accurate data on both vertical and horizontal movements must be obtained to approach the matter satisfactorily, irrespective of whether estimates of the probable future subsidence and horizontal movements are determined from structural analysis, from a graphical study, from a mathematical model or physical model, or from the simple procedure of extrapolating known past occurrences into the future.

Remedies

Remedial work, in one form or another, was commenced as early as 1940, when a few structures built by the Long Beach harbor department near the ocean were arbitrarily constructed several feet higher than they normally would have been. This was to allow for a minor change in elevation of the earth's surface. Some other agencies were influenced by the harbor department's action. More active surface remedial work was initiated about 1945, when it became evident for the first time that the magnitude of subsidence was going to be much greater than previously anticipated.

All predictions contemplate that the deceleration in rate of subsidence, once such a decline becomes marked, will be fairly rapid. These forecasts anticipate that it will require a number of years before subsidence is terminated. Principal differences in opinion concern the time required before cessation of subsidence and the total amount of subsidence.

Every agency which owns property so located that it might be seriously affected at the surface is realistic in its planning and is now doing surface remedial work. This was slow at first, but is now rising to a large volume.

Action proceeds cautiously because of the expense and because estimation of future needs is difficult.

The first and most noticeable surface remedial work usually occurs at the waterfront, many miles long. Whether the waterfront is occupied by vacant land, a shipping terminal, a bulkhead, a factory, or an oil field, the owner must prevent flooding at high tide in order to continue operation. Prevention takes the form of nearly every conceivable type of engineering construction work, including raising the height of wharves; their rehabilitation or complete replacement; increasing the height of bulkheads; construction of earth fills and dikes; and building of retaining walls. Such corrective measures are always handled in a manner which prevents the flooding of the more fortunately located lands to the rear. This, incidentally, protects a great deal of property which otherwise would long since have been seriously flooded.

The land behind the waterfront is not immune from trouble. When it subsides to the point where the water table would normally be above the surface, there is a new host of engineering problems, involving disturbed foundations, disrupted utility structures, drainage, and pumping.

The waterfront structures may be elevated to a height which will prevent future occurrence of flooding by high tides. This raising, however, requires a change in the form, elevation, and location of all the access facilities to the rear of the waterfront. Ingress and egress problems will inevitably result in the gradual raising of a large acreage of land near the waterfront properties. This land-raising operation, while it appears to be a radical approach, has proved to be the logical one in most instances, even though it necessitates the physical raising of important structures, the placing of heavy and deep earth fills, and the complete reconstruction of utilities of all types. Such a remedial program permanently eliminates all ground water problems. It eliminates very serious drainage and foundation problems. It means that every utility which is salvaged, raised, and relocated so as to be adaptable to the new elevation will have been freed of stresses accumulated over the years. These stresses are a result of the horizontal movements incident to subsidence. The hazard of unexpected breaks in oil, gas, sewer, and water lines, of which there is a heavy network throughout the area, will be greatly lessened and comprehensive planning eased.

Differential-Movement Stresses

Horizontal surface movement responsible for utility troubles is such that the differential movement near the center of the subsidence bowl results in severe compression stresses. Near the perimeter of the bowl, there are important tensile stresses. At the point of inflection, or transition, there is a constantly changing stress condition, with initial compression stresses being partly relieved as the subsidence bowl expands.

Surface manifestations which require remedial work are broken pipelines, disrupted sewer and storm drain lines, suddenly buckled or bent railroad tracks, disturbances in pavements, and overstressed building units. It has been necessary to replumb, shorten, and jack up bridge structures, and to cut sections from building and wharf structures to relieve stress. It has been necessary to remove, raise, and replace bridges, as well as to "re-

design" a river. Such work is very extensive and varies with local conditions. Horizontal movements obviously will be disturbing to surveyors, to land title companies, and to landowners who are used to having land title descriptions fit the surveys.

Horizontal movements of the earth's surface in various affected areas take the form of direct shortening, direct lengthening, and changing from one direction of movement to another. As a result, undergound pipelines are seriously affected and there have been many breaks resulting in expense and inconvenience. Subsidence often changes ground water conditions. Localized differential settlements may be due to changes in soil characteristics and the different effects of ground waters upon these soils. Frictional stresses of the ground on rigid structures, either within or on the surface, rapidly exceed the structural capacity of the material to withstand them. In the Long Beach harbor district, it is probable that most water lines must be abandoned in place as land is filled. This is necessary to maintain services, and is certainly an unexpected expenditure for a water utility.

Conclusion

The subsidence problem at Long Beach has necessitated a great deal of research into occurrences which may be taken for granted elsewhere. The authors are convinced that subsidence phenomena are prevalent in many areas where there is little awareness of it. The authors have yet to observe an older oil field where sufficient data will not show subsidence. Technical literature and available survey data provide a ponderous record of subsidence in water-producing areas which relates closely to water pressure drawdowns.

The performance of sands, clays, and shales under changing conditions of water saturation and pressure is becoming well known through the science of soil mechanics. It is believed that the oil and other industries may, over the years, have attributed to other factors well and pipeline derangements properly attributable to subsidence.

The experience at Long Beach demonstrates the importance of subsidence as a threat to utility structures and operations. The possible effects of this phenomenon and the attendant physical forces might well engage the attention of responsible management. Above all, it is desirable to learn as much as possible about subsurface conditions early in the process of subjecting a three-dimensional underground mass to hitherto nonexistent forces.

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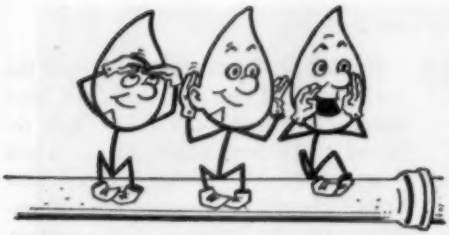


Percolation and Runoff

Davy Jones' locker is being looked to more and more as the storage place of man's future. Not just the water works man's future, either—though in many a drought-bound community his eagerness to get the bounding main into his own mains knows no bounds—but everyone's future in increasing measure as the world's population grows and its land resources are exhausted. Among other things, the sea is an inexhaustible source of chemicals and metals. From it we already extract bromine and magnesium, and with 6,000,000 tons of magnesium in a cubic mile of sea water, it does look as though we shall never want for milk of magnesia. Considering the tons of gold, tons of iron, and relatively tremendous quantities of the rare metals to be found in that same cubic mile of ocean, we can almost overlook the mere 9 tons of uranium it also contains. After all, the sea offers us energy in a lot more available forms than that—in the motion of its waves, its surf, and its tides, as well as in the temperature difference between the waters of its surface and those of its depths. And now to cap its contributions, the sea seems to offer us the best prospect of feeding our future billions. Not just on Fridays either, with the kind of fish and sea food that now comprise a bony or gloppy 1 per cent of our total food supply, but every day and forever with a microscopic menu of appetizing algae.

It is the Chlorellae—fastest growing of the one-celled algae—that have been selected by science as the soundest substitute for meat and potatoes. Like most such organisms, in making exceptionally efficient use of sunlight and in producing a minimum of inedible material, the Chlorellae lend themselves particularly well to being farmed. Not only can crops of 40 tons per acre per year be produced, but, by control of their environment, these algae can be made to yield almost any desired combination of protein and fat, their constituents ranging from 7 to 88 per cent protein, 6 to 38 per cent carbohydrate, and 1 to 75 per cent true fat. Surprisingly, not the nonfattening, but the nutritive, angle has received the greatest attention to date, first attempts to introduce the Chlorellae into our normal diet having been made by two Japanese nutritionists who used them as enriching agents in French bread, noodles, ice cream, and Japanese-style green tea. How nourishing this powdered plankton turned out to be has not yet been revealed, but the organ-

(Continued on page 36 P&R)

(*Continued from page 35 P&R*)

isms did, it is reported, produce "an agreeable light-green color," which, if it doesn't revive the chlorophyll craze, may be found to serve some useful purpose in the French bread, anyway, as a camouflage for moldiness.

Any water worker worth his salt ought to be able to put this new "look-sea" trend to his own advantage. Having waited so long for science to find a way to bring the cost of distilling sea water within reach of public water supply, he now ought to be able to bridge the gap himself with byproducts. After all, if he can't make up the present differential of a dollar per million gallons by straining a few meals out of the raw water and by selling dregs just loaded with bromine, magnesium, iron, gold, uranium, and even praseodymium, maybe he ought to forget the fresh water and enrich himself. Who's thirsty anyhow?

Home disharmony as the cause of dental caries in children is a new theory advanced in a recent issue of the *British Dental Journal*. In support of the hypothesis, the dentist who presented it cited statistics proving that children's dental troubles are "exactly in proportion to the degree of apprehension" caused in a child by spats, tiffs, and sundry altercations between his parents. Actually, of course, our British friend somehow managed to invert his conclusion. Obviously, it is dental caries in children which cause home disharmony. We could hardly need more proof of this than the rapid decrease in the US divorce rate since 1946, when the effects of the first fluoridation programs began to make themselves felt in improved dental health for children. Those reverse English!

Daniel N. Fischel, who joined the JOURNAL staff in 1946 and has been managing editor since 1947, has resigned to become editor of the Book Dept. of F. W. Dodge Corp., New York. He will continue as unpaid consultant on the JOURNAL filing system, with the title of Dowser & Interpreter of Obsolescent Memoranda. And, of course, he is expected to remain an Editor Anonymous in good standing.

Civil service status of chemists employed by New York State was the subject of a hearing held before the State Dept. of Civil Service on Feb. 15. Representing AWWA, F. W. Gilcreas, assistant director of the Div. of Labs. and Research, State Dept. of Health, made the following statement:

The American Water Works Assn. includes among its more than 10,000 members a large number of chemists, most of whom are employed in governmental positions, and the balance in industry. Thus, the Association is much concerned with any action the Dept. of Civil Service of the State of New York takes in relation to the status and classification of salary grades of chemists, particularly of sanitary chemists. Any action New York State initiates will obviously have great influence in other areas in which the members of this Association are interested. The American Water Works Assn. is very definitely of the opinion that chemists are professional workers and that their status and pay should be commensurate with their qualifications and their duties, and that these qualifications and duties are equal to those of corresponding engineering positions. The existing discrimination in salary grades in New York State against chemists, especially sanitary chemists, as compared with engineers, particularly sanitary engineers, causes much concern to the Association. The American Water Works

(*Continued on page 38 P&R*)

Vacuum Pressure Pump
Cat. XX 60 000 00

Hydrosol Standard
Filter Holder with Sterilization
Base and Cover
Cat. XX 20 047 00

Millipore
Filters
(Box of 100)

Plastic (Disposable)
Petri Dishes
(Box of 10)

MILLIPORE MF FILTERS

In the analysis of • Bacterial Contaminants • Total Counts • Coliforms • Soil Organisms

ACCURACY — The MF® has been described as the equivalent of six (6) 5-tube MPN's.*

SENSITIVITY — The isolation and identification of specific pathogens by the MF is often possible when other methods fail.†

RELIABILITY — Reproducible results occur time after time. Standard deviation less than half that of MPN. $\sigma_{MF} < \frac{\sigma_{MPN}}{2}$

LESS COSTLY — The reduction in cost per test permits wider and more frequent monitoring of water supplies for corrective action.

MORE RAPID — Total counts in as little as four (4) hours; confirmed tests in sixteen hours versus three to four days with other methods.

SIMPLE TO USE — Routine analyses require no extensive training in operation or in interpretation of results.

A comprehensive summary of literature in many new techniques and a complete line of accessory equipment are available from the laboratories of the

MILLIPORE FILTER CORPORATION
Watertown 72, Mass., U. S. A.

*Woodward, 1952, EHC Activity Report 11:13 Jan.-Mar.
†Collet, Johnston, Ey, Croft, 1953 J. Amer. Public Health Assn. 43:1438-40 November.

(Continued from page 36 P&R)

Assn. urges that every consideration be given to the reclassification of chemists' titles in order that their status in New York State may be the same as that of persons in other technical disciplines, particularly sanitary engineers, with whom sanitary chemists must work in close cooperation.

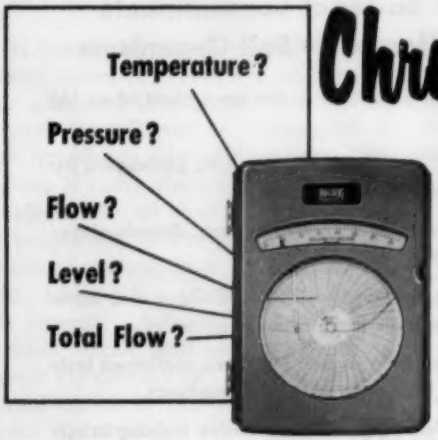
Cast-iron stomachs can now be cement lined through a process developed by scientists of Winthrop-Stearns, Inc., Rensselaer, N.Y. Actually, the process was developed as a means of coating rather than lining, the cement being applied to the outside of tablets containing medicines strong enough to injure the lining of the mouth. By the use of a coating capable of withstanding pressures up to 33 psi, it is assured that the tablets will be swallowed rather than chewed. The lining then forms as the coatings are shed in the stomach, which just must be cast iron to be able to take what the mouth can't.

All this, of course, is quite a blow to the water works field, for normal pills are taken "with a glass of water," but cement, neat.

Charles A. Fisher has been appointed plant manager of the Maywood, Ind., plant of Reilly Tar & Chemical Corp.

Norman W. Rowand, general manager of the Pittsburgh Div., Rockwell Mfg. Co., has been appointed assistant to the vice-president. He is succeeded by Paul A. Mankin, division chief engineer. Arthur W. Krause, assistant general manager, has been made factory manager.

(Continued on page 40 P&R)



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By transmitting and receiving information over a simple two-wire circuit, Builders CHRONOFLO TELEMETERS produce important economies for water and sewage plants.

(1) Chronoflo saves time—gives immediate indications of changes in flow, total flow, pressure, temperature, level.

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Chronoflo is one of the many Builders systems for modern plant operation. Write for Bulletin 230-H4. Builders-Providence, Inc., 365 Harris Avenue, Providence 1, Rhode Island.

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BIF METERS FEEDERS CONTROLS

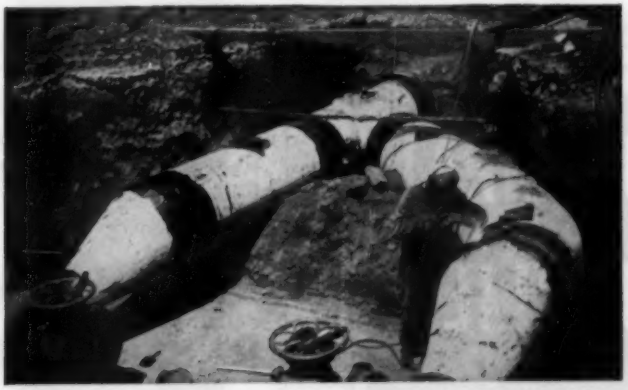
STEEL PIPE solves headroom problem as Newark modernizes vital water control station

In Newark, the Bloomfield Avenue Tower is the vital terminal for five of the City's six main feeder lines. Modernization at the Tower called for critical selection of new pipe for maximum strength and flow in minimum headroom.

The problem was solved with 1650 ft of 48-in., 450 ft of 36-in. and 30 ft of 60-in. Alco Electric Welded Steel Pipe. Through it will surge more than 85 million gallons of water per day.

Furnished in diameters from 20 to 120 in. and lengths to 40 ft, Alco Electric Welded Steel Pipe is specified the country over for its engineered strength, efficiency, economy and long life.

Use it in your installation, be it large or small, special or standard. Your Alco Products sales representative will be glad to give you complete technical data—plus expert help on your own special problems.



CITY OF NEWARK uses strong, efficient Alco Electric Welded Steel Pipe in 36, 48 and 60-in. diameters and special sections (shown above) at vital Bloomfield Tower control station.

Remember these Key features of Alco Steel Pipe:

STRONG • EFFICIENT • ECONOMICAL
DURABLE

ALCO
PRODUCTS
AMERICAN LOCOMOTIVE COMPANY
Sales and Service Offices in Principal Cities

(Continued from page 38 P&R)

Caterpillar Tractor Co. is now marketing a line of ten mobile and skid-mounted diesel electric generating units, with a power range of 18–300 kw. These are offered in standard packages, with optional features available.

A new steel safety floor armor has been developed by the Klemp Metal Grating Corp., Chicago. The $\frac{3}{8}$-in. × 16-gage hexagonal steel mesh ("Hexteel"), filled with hot or cold mastic, can be used on new or existing concrete or wood flooring.

No more gravy from New York City hydrants was the word from Water Commissioner Arthur Ford's office last December, announcing the end of 30 years of political patronage for district leaders. With the appointment of regular civil service employees to the job of fire hydrant inspector, the department also instituted a policy of requiring payment of the inspection fees in advance and to the department, where previously they had been collected and kept as their remuneration by the political appointees. Inasmuch as inspections are required daily whenever contractors use city water in their operations, the gravy in the most active areas of the city was found to have totaled as high as $13,655 per year. More affluent than effluent.

D. T. Bixby has been named sales manager of the Standard Products Div. of the De Laval Steam Turbine Co., with headquarters in Trenton, N.J. Mr. Bixby was formerly with the company's Seattle, Wash., office.

(Continued on page 42 P&R)

MUNICIPAL SUPPLIES
No. 152
ESTABLISHED 1906—47 YEARS OF SERVICE
W.S. DARLEY & CO.
CHICAGO 12 ILLINOIS
WRITE TODAY
For
100 PAGE CATALOG
W. S. DARLEY & CO. Chicago 12

For Organic Iron and Color Removal—Algae Control—Regeneration of Iron Removal Filters—
Use
POTASSIUM PERMANGANATE
Supplied to industry and municipalities in various grades and meshes to fit the particular operation, efficiently and economically in combating many water problems.
WRITE FOR QUOTATIONS
CARUS CHEMICAL COMPANY
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LOW COST

"CENTURY" PIPE

is made of asbestos fiber and portland cement—two practically indestructible materials. Its extreme durability means extra long life. Highly resistant to soil corrosion, immune to tuberculation, and electrolysis, it assures maintenance-free service and consistently lower pumping costs.

More and more cost and tax-conscious communities are turning to "CENTURY" Pipe. We will gladly furnish information about its advantages. Write today for booklet "Mains Without Maintenance."

QUALITIES THAT MAKE "CENTURY" PIPE ECONOMICAL, TROUBLE-FREE, LONG-LIVED

1. NON-TUBERCULATING
2. NON-CORROSIVE
3. EXCEPTIONALLY STRONG
4. DURABLE
5. IMMUNE TO ELECTROLYSIS
6. TIGHT JOINTS
7. SMOOTH BORE
8. EASILY, QUICKLY LAID
9. LIGHT WEIGHT
10. LOW COST

"Century" Pipe meets the A.W.W.A., A.S.T.M. and Federal Specifications for asbestos-cement pressure pipe.

KEASBEY & MATTISON COMPANY • AMBLER • PENNSYLVANIA

Nature made asbestos . . . Keasbey & Mattison has made it serve mankind since 1873

(Continued from page 40 P&R)

The highwaymen, with whom AWWA has been struggling on the question of liability for the cost of moving utility structures to accommodate highway relocations, managed to sneak in a couple surprise punches during the past month. First of these was at New Rochelle, N.Y., where the water company itself was forced to move, its own office building being scheduled for destruction to make way for a new "super expressway." The other was at Grassy Point, N.Y., where, in the process of completing a new bridge, the contractors moved the town's water mains from their regular bed, under the creek being bridged, to an exposed position under the structure. With the temperature at five below, the water froze solid, leaving the town completely dry and, thus, helpless to prevent the total destruction of its 100-year-old inn, when it caught fire at three in the morning. These, of course, are quite beside the highway relocation point, but they do sort of rub it in.

Ross Engineering of Chicago has been appointed representative for Hungerford & Terry in northern Illinois, eastern Iowa, and northwestern Indiana.

David M. McIntosh has been elected executive vice-president of the Chapman Valve Mfg. Co., Indian Orchard, Mass. He retains his position as vice-president in charge of production, while Frank A. Hunter has been appointed vice-president in charge of sales.

(Continued on page 44 P&R)

ELEVATED TANKS

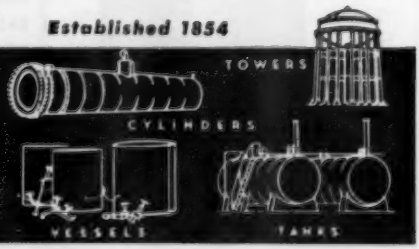
For almost a century Cole elevated tanks have been helping provide uniform water pressure, fire protection and adequate water reserve in scores of American cities.

Capacities 5,000 to 2,000,000 gallons—with hemispherical, ellipsoidal or conical bottoms. Also flat-bottom tanks for standpipe storage. Correctly built in accordance with AWWA specifications.

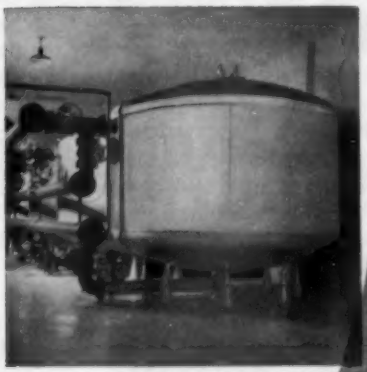
We invite your inquiries. State capacity, height to bottom, and location.

R. D. COLE
MANUFACTURING CO.
NEWNAN, GA.

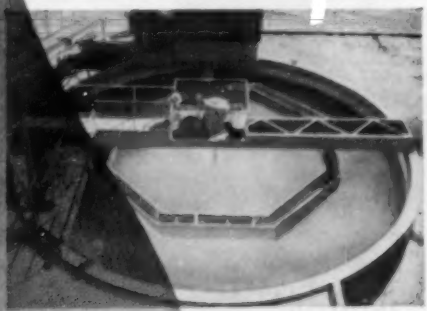
Established 1854



Why General Filter?



There are many reasons why municipalities and industries have installed General Filter water treating plants:



INSTALLATION SUPERVISION . . . General Filter "job-engineers" each installation to the consulting engineer's specification . . . supervises the installation and trains the personnel who will work with the equipment.

OPERATIONAL DEPENDABILITY . . . for twenty years General Filter has concentrated all of its efforts toward "better water treatment". Their efforts have produced water treating plants and equipment that are completely dependable.

ENGINEERING KNOW-HOW . . . General Filter's design and construction engineers are familiar with the problems involved in water treatment.

GREATER ECONOMY . . . the only real test of economy is a long term test. General Filter plants stand up over the years providing "better water" with minimum maintenance, longer trouble-free, smoother operation.

Find out why you should specify General Filter . . . Write today for detailed information regarding your water treatment problems.

General Filter Company
AMES, IOWA
"yours for better water treatment"

AERATORS • FILTERS • TASTE AND ODOR • ALKALINITY CONTROL • HIGH CAPACITY RESINOUS ZEOLITE • IRON RUST REMOVAL • DEMINERALIZATION • SOFTENERS

(Continued from page 42 P&R)

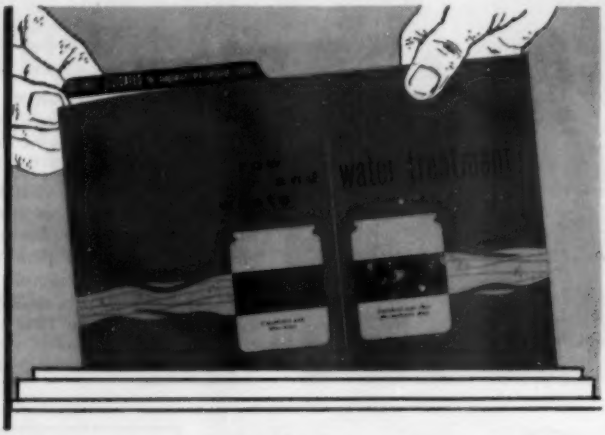
Rutgers University announces the availability of research fellowships in its Dept. of Sanitation. The one-year grants are open to residents of the United States and Canada with the requisite education and training to be acceptable for graduate study. Further information and application forms may be obtained from: Dr. Harold E. Orford, Chairman, Dept. of Sanitation, Towers Bldg., Rutgers University, New Brunswick, N.J.

The moonshine's blight in our old Virginny home seems to be the same as water's. Drought, that is! Thus, last year's drydom made happy hunting for Virginia's revenue agents, who reported finding a large number of moonshine stills abandoned in dry creek beds for lack of water to operate them. All of which may prove that Virginia's drought was worse than that in Georgia, where, throughout the desiccation, the Anti-Moonshine League Inc. found it necessary to continue advertising its rewards to taxpayers for volunteering information on the location of stills and moonshine spirits (the kind that blind, not haunt). In the South, it seems, the more rain, the more moonshine.

P. H. Beauvais, city manager of Allegan, Mich., was hailed recently by the International City Managers' Assn. as the only active city manager with more than 25 years of service. His managerial activities began in Manistee, Mich., in 1918.

(Continued on page 46 P&R)

data file on treating raw and waste waters with **Activated Silica Sols**



• Request on your plant stationery, useful bulletins and reprints discussing the advantages of activated silica sols as coagulating aids, how to prepare these sols, information on the N-Sol Patented Processes.

PHILADELPHIA QUARTZ COMPANY
1142 Public Ledger Bldg.
Philadelphia 6, Pa.
PQ® SOLUBLE SILICATES

N-SOL® PROCESSES...
for preparing activated silica sols from N® silicate are licensed without royalty.

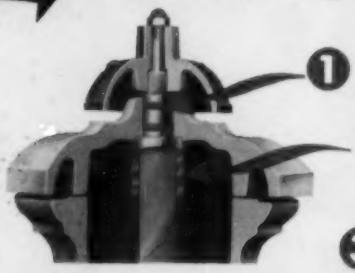
TRADE LUDLOW MARK

NEW

A.W.W.A.

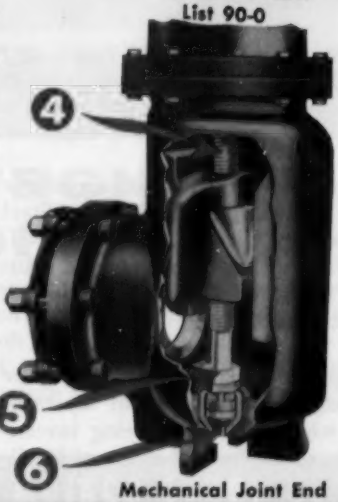
FIRE HYDRANTS

NO Stem Breakage!



List 90-0

1. **LESS OPERATING TORQUE!** New, non-binding upper and lower "O" rings trap lubricant . . . assure positive watertight seal . . . require no servicing.
2. **POP-OFF SLEEVE COUPLING** releases hydrant head from stem in event of traffic damage.
3. **GROUND LINE FLANGE** eliminates digging.
4. **90,000 TENSILE STRENGTH** Rolled Everdur threaded stem section completely eliminates stem failure.
5. **NO FLOODING.** Closed hydrant remains locked — even in event of traffic accident.
6. **NO FREEZING.** Positive drip action, at extreme bottom, assures complete drainage.



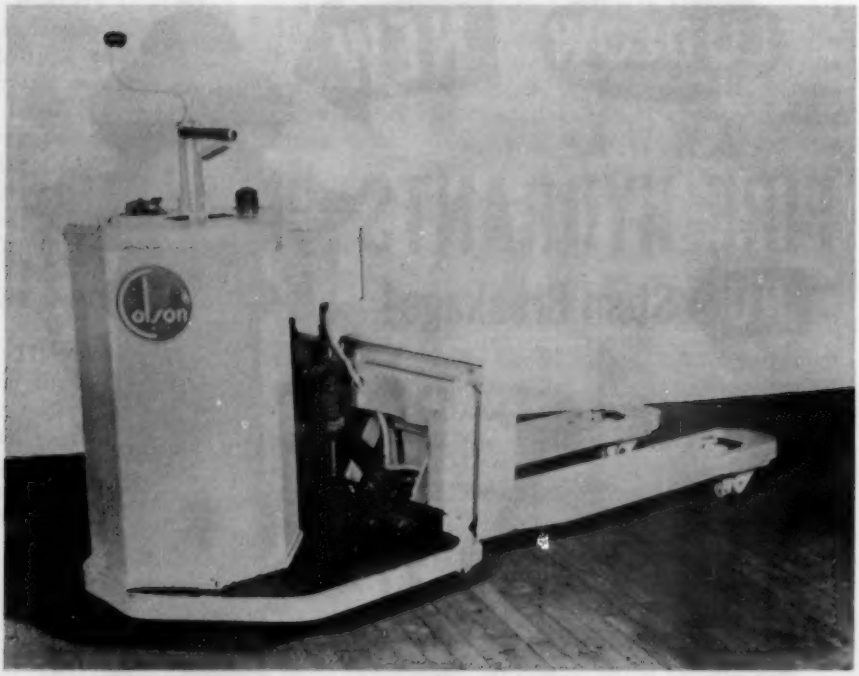
Mechanical Joint End

THE LUDLOW VALVE

ESTB. 1861 MFG · CO · INC · TROY · N · Y ·

CANADIAN LUDLOW VALVE MFG. CO., LTD., MONTREAL

(Continued from page 44 P&R)



This 4,000-lb capacity fork truck, controlled by a single lever, is being introduced by the Colson Corp., Elyria, Ohio, manufacturers of material-handling equipment. The truck unit is 29 in. wide and 30 in. long, with fork lengths of 32–60 in. available.

C. R. Ford is the new sales manager of the Pittsburgh-Des Moines Steel Co. Eastern Dist., at Newark, N.J. J. S. Marriott has been appointed manager of structural sales for the Midwest Div., at Des Moines, Iowa.

Evapoproofing of reservoirs by the spreading of monomolecular layers of sperm whale oil is now being investigated in more than 40 different localities in Australia. Results indicate that the oil—cetyl alcohol—which spreads thin enough so that a pound will cover an acre, reduces evaporation by about 30 per cent at a cost of approximately 1¢ per 1,000 gal saved. Just what the whale does with this valuable stuff we're not at all certain, but since we've never noticed anything particularly perfumy about a whale, either, we're content not to inquire as long as we are assured that the oil is not detrimental to either the taste or the safety of the supply. Certainly if the present investigations prove the present claims, those who can't cover should cetaceate!

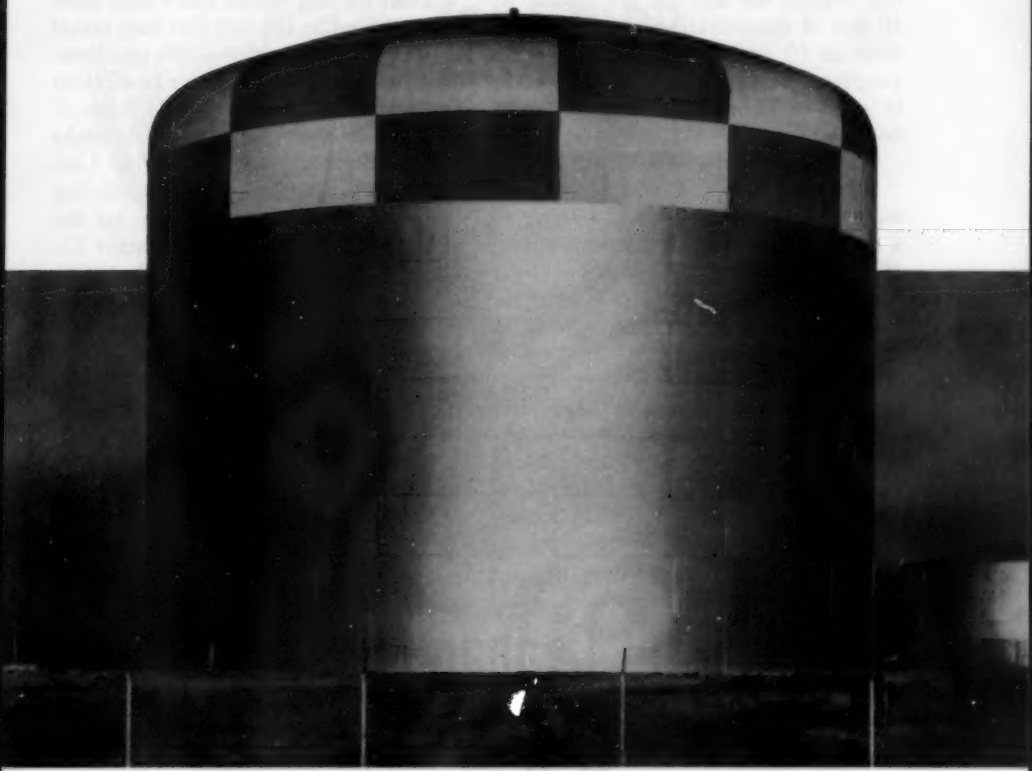
A mixed-bed demineralizer unit, Model R-M-8, has been developed by the Penfield Mfg. Co., Meriden, Conn. Usable either as a monobed or two-

(Continued on page 48 P&R)

America's Largest Standpipe

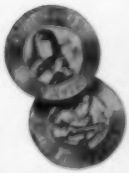
(CAPACITY 7,268,000 GALLONS)

for South Pittsburgh Water Company



by PITTSBURGH • DES MOINES

This huge water storage unit evidences typical Pittsburgh-Des Moines fine workmanship in shop fabrication and field erection. Measuring 116 feet in diameter, with a water depth of 95 feet and total capacity of 7,268,000 gallons, the South Pittsburgh Water Company giant is the largest standpipe-type storage tank built in America to date. • Let us quote on your water storage needs.



PITTSBURGH • DES MOINES STEEL CO.

Plants at PITTSBURGH, DES MOINES and SANTA CLARA

Sales Offices at:

PITTSBURGH (25), . . . 3424 Neville Island
NEWARK (2), . . 221 Industrial Office Bldg.
CHICAGO (3), 1228 First National Bank Bldg.
LOS ANGELES (48), . . 6399 Wilshire Blvd.
DES MOINES (8), ... 925 Tuttle Street
DALLAS (1), . . . 1229 Praetorian Building
SEATTLE . . . . . 532 Lane Street
SANTA CLARA, CAL. . . . 631 Alviso Road

(Continued from page 46 P&R)

bed system, the unit can produce up to 10 gph of demineralized water with as little as 10 grains of sodium chloride (expressed as $CaCO_3$). Regeneration is said to be simple, fast, and economical.

Badger Meter Mfg. Co. of Milwaukee has announced the opening of a new $600,000 foundry at Fall River, Wis. The plant will produce about 400,000 lb of brass castings (for liquid meters) monthly, and is capable of expansion.

The Portland Cement Assn. has announced several appointments as district engineer: Thomas D. Shiels, Austin, Tex.; Harold G. Garner, Kansas City, Mo.; and Kenneth B. Lucas, Omaha, Neb.

That oil and water don't mix must be explained by the fact that they travel around in different—well—pipelines. Just how different ought to be obvious enough from the fact that 24 miles of 30-in. line was laid in only 4 weeks for the Panhandle Eastern Pipe Line Co. in Kansas, using a new pipelaying machine developed specifically for the purpose by the Caterpillar Tractor Co. But even such speed is hardly worth the mention compared with that of the Service Pipe Line Co., which put in an oil line between Fort Laramie, Wyo., and Freeman, Mo., last fall—625 miles of 20-, 22-, and 24-in. pipe in just 61 days.

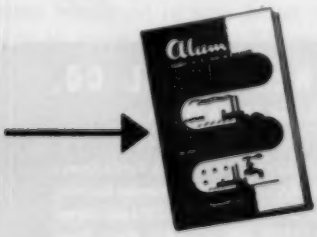
Gas line, fortunately, has been a little less jet propelled. Fortunately, at any rate, for the town of Nashville, Ark., which ran completely dry last

(Continued on page 50 P&R)

Depend on Cyanamid's ALUM for 6 good reasons

1. It feeds uniformly, without trouble, in solid or liquid form.
2. It has a wide pH range for effective coagulation.
3. It forms floc rapidly.
4. It gives maximum adsorption of suspended and colloidal impurities.
5. It causes minimum corrosion of feeding equipment.
6. It is available in granular form or in the new easy-to-use liquid form.

For a copy of "Alum—Commercial Aluminum Sulfate," please send us your name and title on company stationery—and would you also mention where you saw this offer?



AMERICAN Cyanamid COMPANY
Heavy Chemicals Department
30 Rockefeller Plaza, New York 20, N. Y.

In Canada: North American Cyanamid Limited, Toronto & Montreal

for Small Communities

Typical "ACCELAPAK" Installation

ACCELAPAK Packaged Plants

(Trade Mark)

for Complete Water Treatment

Here is the answer to the water needs of small communities, camps and resorts, estates and industrial plants—the "ACCELAPAK" treating plant—producing the best water obtainable with a minimum of operating supervision and at the lowest cost.

Designed for capacities as low as 15 g.p.m., operation of this plant is simplicity itself with "once a day" charging of chemical feeders and electric interlocks to start and stop the plant from float switch in the clearwell.

Write for illustrated literature, or ask your consulting engineer.

INFILCO

The one company offering engineered equipment for all types of water and waste processing—coagulation, precipitation, sedimentation, flotation, filtration, ion exchange and biological treatment.

INFILCO INC.

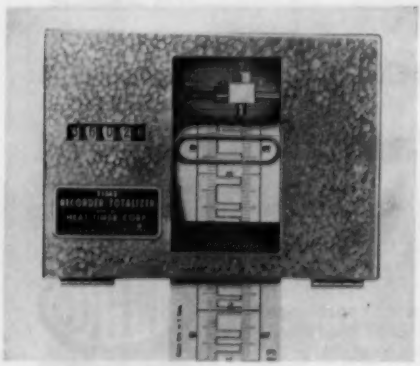
925 S. Campbell Ave., Tucson, Arizona

Field offices in principal cities in North America 5334

(*Continued from page 48 P&R*)

August after 100 days of severe drought during which it pumped dry every puddle, pond, and stream in the vicinity, and then was saved by the 2-week loan of a 9-mile stretch of the still uncompleted gas line running from Nashville to neighboring Murfreesboro. By authorization of Murfreesboro officials and the community-minded cooperation of the Arkansas Louisiana Gas Co., which donated its equipment and time to making the quick change, the 9-mile stretch of line between Nashville and the Little Missouri River was equipped with the necessary pumps and connections and put to work carrying 175 gpm back into Nashville's reservoir. Not just a transfusion, but a borrowed artery as well. And if 72 hours of around-the-clock activity to get a 9-mile stretch of already installed line hooked up and working sounds a little sluggish oil-wise, the water was certainly worth the wait.

A recording device marketed by the Heat-Timer Corp., New York, uses



chronologically marked tape to provide a continuous operation record of any electrically operated machine or process (see cut). In addition, a "totalizer" shows the total time in operation. The device is priced at $55.

George S. Lee has been appointed superintendent of the water works at Cedar Rapids, Iowa. Mr. Lee came to Cedar Rapids as chemist-bacteriologist in June 1954. He replaces H. F. Blomquist, who had come out of retirement to act as superintendent.

Rudolph E. Thompson has been named director of purification and sewage treatment laboratories at Toronto, Ont., a position left vacant by the retirement of Norman J. Howard. Mr. Thompson's advancement is the JOURNAL's loss, as his new duties will prevent him from contributing to its "Condensation" section, of which he has long been a mainstay.

Ellis S. Tisdale has been appointed director of the Interstate Commission on the Potomac River Basin, effective Jul. 1, 1955, the date of his retirement as sanitary engineer director of the US Public Health Service. On Mar. 1, Mr. Tisdale was transferred from his post as regional engineer at Atlanta, Ga., to Washington headquarters to assist in an interagency project for establishing a roster of sanitary engineering manpower resources in the United States. Howard Chapman, formerly head of the Interstate Carrier Program, USPHS, Washington, replaces Mr. Tisdale at Atlanta.

Mush was what Willing Water said when he was invited up to Anchorage, Alaska, to host the "First Alaska Water Works Operators School," sponsored jointly by the Univ. of Alaska, the Alaska Dept. of Health, and the Arctic Health Research Center. Gush was what Willing Water did on Feb. 2 at the end of 2½ days of sessions which gave the latest word on all aspects of

(*Continued on page 52 P&R*)

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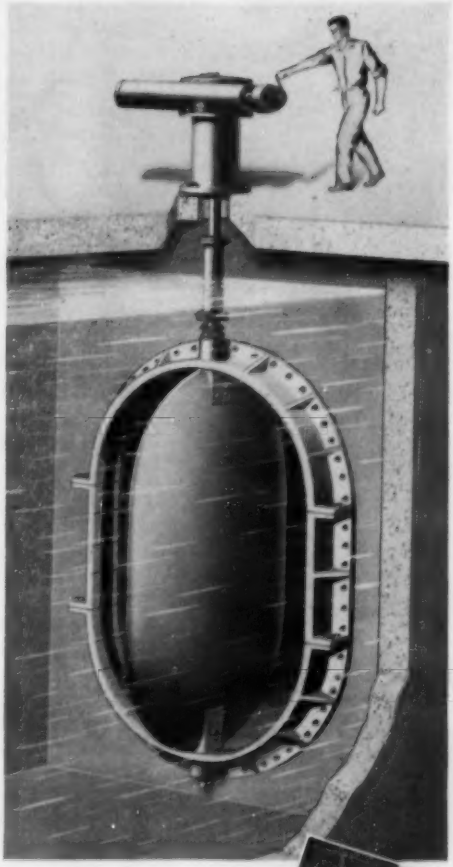

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(Continued from page 50 P&R)

water works operation to the more than 100 who attended and received school certificates. What flabbergasted Willie more than anything else was the number who attended, educating him to the fact that his blubber and ice picture of this part of AWWA's Pacific-Northwest Section was just a little archaic. Mushy is the word for Willie now in talking about Alaska and Amos Alter and the Anchorage agenda.

Arthur E. Williamson, formerly director of the Div. of Munic. Eng., North Dakota Dept. of Health, has been named director of the Div. of Environmental Sanitation, Wyoming Dept. of Public Health, a position left vacant by the death of Leonard O. Williams.

Stephen D. Moxley, former executive vice-president, has been named president of the American Cast Iron Pipe Co., Birmingham, Ala., succeeding Charles O. Hodges, who is retiring after 38 years of service. Others who have assumed top posts are: Arnold J. Hermann, who becomes vice-president and sales manager; Frank H. Coupland, vice-president and works manager; Kenneth R. Daniel, vice-president and chief engineer; and A. E. Bowen, treasurer.

Leigh W. Morrill, formerly with the New Jersey Dept. of Health, has been named water superintendent and borough engineer for Essex Fells, N.J., replacing E. Arthur Bell, who left to become chief engineer for the Stamford (Conn.) Water Co.

(Continued on page 86 P&R)

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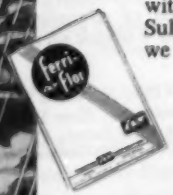

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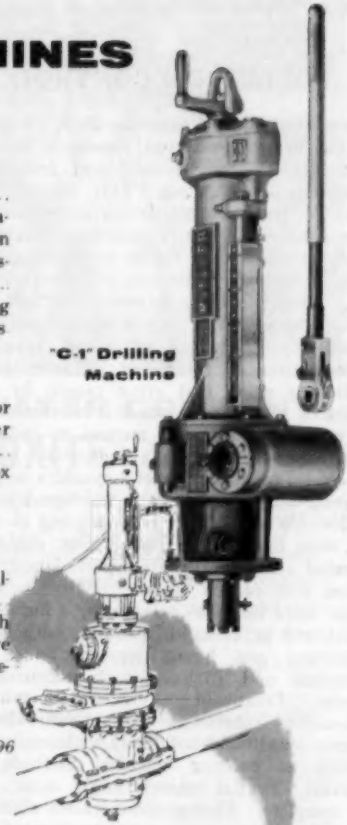

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

POLLUTION CONTROL

Water Pollution Research, 1953. Report of the Water Pollution Research Board. British Dept. of Scientific and Industrial Research, London, Eng. ('53). 62 pp. *Removal of radioisotopes during normal treatment of domestic water supplies.* Discusses work on removal of fission products, strontium 89 and 90, ruthenium 106, and cerium 144. Most work was concerned with radiostrontium, as this is one of most dangerous possible contaminants of water supplies. *Determination of dissolved oxygen.* Suggestion is made that error caused by use of starch as indicator can best be eliminated by using amperometric method to indicate endpoint in titration. *Industrial waste waters.* Treatment of metal cyanides in percolating filters is discussed and found practicable. Waste waters from kiering of cotton, even though strongly alkaline, could be digested anaerobically after partial neutralization with carbon dioxide. Effluents from silage were found to be strongly pollutional. Treatment by biological filtration of sewage containing gas liquor was continued at Stivichall and Finham, with encouraging results. Treatment of effluents containing radioactive substances by activated-sludge process was found not likely to be so satisfactory as existing chemical methods of removal. Partial removal might occur, but not complete. Photographic wastes containing silver compounds may be treated by electrolysis for recovery of silver. Spent solutions from fixing prints can then be reused after addition of fresh thiosulfate. Spent developer cannot be reused. Effects of polluting substances on fishery were studied on Colne R. and estimates of coarse fish population made. Toxicity of ammonia and gammexene was also investigated and evaluated. Survival of bacteria in polluted stream below effluent discharge of Maple Cross Works of Colne Valley Sewerage Board was explored. Marked decrease was noted. Principal topic considered was survey of Thames estuary, and statistical examination of records. Oxygen sag is indicated. Oxygenation of estuary has declined since '35. Photosynthesis is noted as flow approaches mouth of river. Temperature of estuary is affected chiefly by discharge of cooling water from electrical generating stations. Rate of oxidation of polluting matter is discussed from laboratory standpoint. Nitrification in estuary water occurs, involving large quantities of oxygen. Bottom deposits are important, even though Port of London Authority dredges out of estuary and dock systems 3,000,000 tons of mud (wet weight) annually and deposits it at sea. Attempt was made to measure in laboratory oxygen demand of some bottom deposits, which checked fairly closely with field determinations. Absorption of oxygen from air was studied on small scale in field. Whereas photosynthesis is very active at seaward end of estuary, it proved difficult to estimate its effect on oxygenation of Thames water. Field observations show high DO content when 35 mi or more below London Bridge. Reduction of sulfate to sulfide is suspected and was demonstrated in laboratory tests on mud removed from river. Distribution of suspended solids was checked by field observation. Distribution of fecal bacteria was examined, counts for *Str. faecalis* being consistently lower than for *Esch. coli.* Complaint of corrosion of ship propellers in estuary water was investigated, and it is surmised to be due to presence of sulfide.—*PHEA*

The Total Number of Bacteria and the Rate of Oxygen Utilization in Waters of Various Degrees of Pollution. G. G. Vinberg & M. S. Lomonosova. Microbiol. (USSR), **22**:294 ('53). Study was made of water from Svislotch R. at different points

(*Continued on page 64*)

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(*Continued from page 62*)

in its course through town of Minsk, USSR, to determine relation between degree of pollution and numbers of bacteria. Samples of water examined were unpolluted, slightly polluted, and heavily polluted. Numbers of bacteria in samples were determined by direct counting. It was found that there was direct relation between BOD of water and total number of bacteria, but in winter total number was considerably less than in summer for same BOD value. From determination of rate of uptake of oxygen in samples of water stored in bottles, amount of oxygen used by individual bacterial cells was calculated. Results obtained for polluted and unpolluted water were found to be similar. During period of rapid multiplication of bacteria, uptake of oxygen per bacterium was about 0.5×10^{-9} mg in 24 hr at 20°C, and during subsequent period, when bacteria were not multiplying, amount of oxygen utilized by single cell in 24 hr at 20°C ranged from 0.05×10^{-9} mg to 0.15×10^{-9} mg.—*WPA*

Polluting Character of Silage Effluent. E. E. Jones & J. C. Murdoch. Wtr. & Sanitary Engr. (Br.), 5:54 (Jul.-Aug. '54). That silage effluent would cause serious pollution if discharged directly to watercourse has been shown by experiments carried out at National Institute for Research in Dairying (England) in harvest seasons of '52 and '53. Observations taken on effluent from meadow fescue-timothy grass in covered brick tower silos showed avg BOD of 54,590 ppm, this effluent being about 220 times as polluting as average settled domestic sewage (BOD 250 ppm). Effluent from chopped grass was more acidic and contained more organic matter than unchopped grass, and was discharged more quickly. When silage has dry-matter content of 30% or greater, little or no seepage takes place; this level can be reached by allowing crop to wilt in field for 6–12 hr after cutting. Pit and clamp silos, which discharge effluent directly to ground, are subject to leaching of nutrients and production of more

(*Continued on page 66*)

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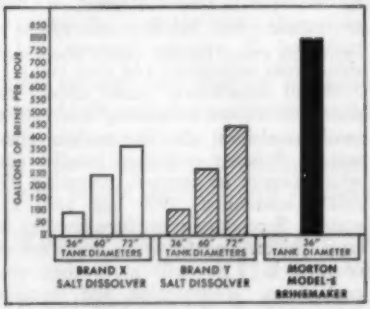

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(Continued from page 64)

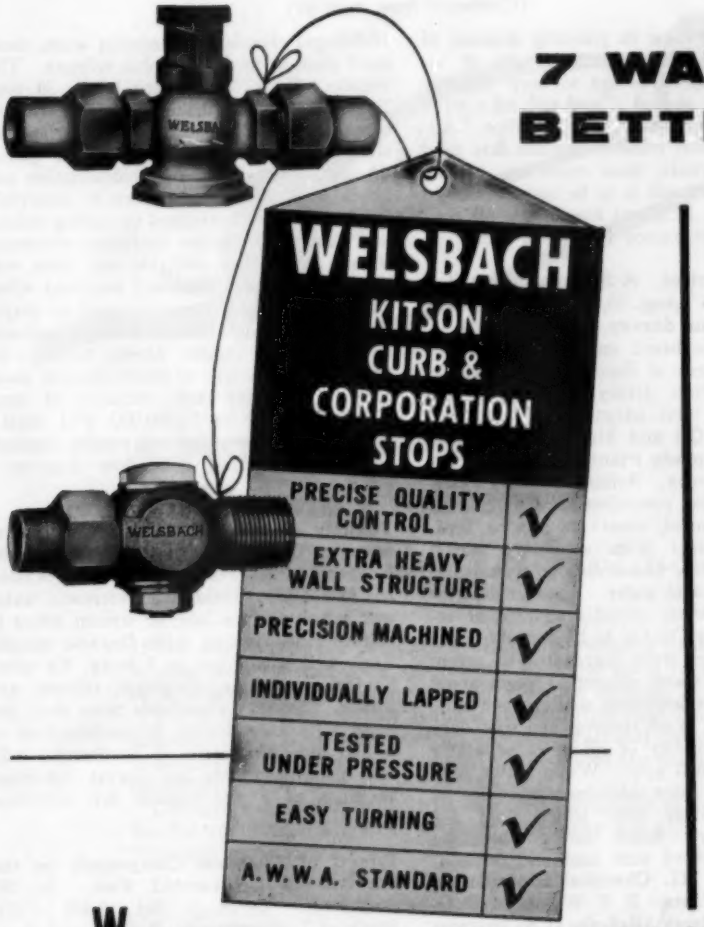
effluent by action of rain water; roofing of silos is recommended. Only practicable way of disposing of effluent is controlled drainage to surrounding ground.—*PHEA*

The Ecology of Alamitos Bay, California, With Special Reference to Pollution. D. J. REISH & H. A. WINTER. Calif. Fish & Game, **40**:105 (Apr. '54). In extensive pollution survey of local waters near San Diego, Calif., it was found that no conditions seriously affecting fish and aquatic life exist in Alamitos Bay, although lumps of asphalt were observed at one station, near oil fields; strong sulfide odor characterized 2 stations on tributary arm; and strong sulfide odor was noted at station near storm sewer outfall and above tidal gates. No sludge beds were found in Alamitos Bay, and there was no evidence of seepage of pollutants from San Gabriel R. into Alamitos Bay. Substratum of bay supports rich and varied fauna, knowledge of which should be of particular value in comparing this region with other Southern California harbors and bays that are affected by domestic and industrial waste discharges.—*SIW*

Analysis of a Stream's Capacity for Assimilating Pollution. M. A. CHURCHILL. Sew Ind. Wastes, **26**:887 ('54)). Ultimate purpose of all stream sanitation activities is to establish and maintain reasonable and economic balance between man's many uses of streams which do not lower water quality, and his use of streams for waste disposal. One prerequisite for establishing this balance is determination of stream's capacity for absorbing pollution. This paper presents method for determining quantitative relationship between organic waste loads put into stream and resulting DO depletion. Among advantages of method are that neither time of water travel nor long-term BOD determinations are required. Its use enables relatively small staff, operating on small budget, to evaluate pollution-assimilative capacity of many streams in short period. Statistical procedures employed to evaluate dependability of relationship developed are given in detail in appendix. Example of method, as applied to specific stream section, is given. For each sampling station, calculation is made of relationship existing between decrease in DO concentration (DO drop) and BOD load per cubic foot of stream flow (ppm BOD times constant). All calculated values for this relationship at each station are plotted. True relationship is approximated by method of least squares. Lines are also drawn to represent 95% confidence limits of true relationship. Using these and other calculated data, and taking into account such factors as normal BOD load of river if pollution in question were not added, normal increase in flow in downstream sections, organic bottom material, and progressive reduction in BOD load due to natural purification processes, graphs are drawn of DO profiles for normal BOD load and various stream flows and for reduced BOD loads and minimum stream flows.—*PHEA*

There's No Water Pollution Here. A. D. MCRAE. Oil & Gas J., **53**:103 (Jul. 12, '54). Describes procedure at Sarnia, Ont., refinery of Imperial Oil, Ltd., to remove contaminants before discharge into St. Clair R. (international boundary), on which refinery is located. Contaminants are removed at source wherever possible, and biological oxidation is employed to remove residual phenolic material and other reducing compounds. Spent caustic soda and sour condensates are neutralized by flue gas and overhead material burned as fuel. Recovered petroleum acids are either burned or sold to chemical companies as basis for plastics or organic chemicals. Solid material collected is dewatered and de-oiled by centrifuges, oil recovered, and solids burned in multihearth furnace. Wherever possible, lines have been put in trenches or elevated above ground, to reveal leaks. Circular separators are used instead of rectangular. Emulsions are broken down. Neutralization by flue gases is practiced (8 diagrams show procedures followed). Biological oxidation handles 0.5 mgd of phenolic material. Disposal plant is designed to handle 900 bbl/day of wastes from tank and oil separator bottoms, and emulsions from separators and slop tanks. Two 3,000-bbl cone-bottom tanks collect various pumpable wastes, containing free oil, water-in-oil emulsions, silt, fine carbon, and 80% water. Primary centrifuge handles material which cannot be pumped, removing 95% of solids containing 19% oil and 15-40% water. Secondary centrifuge handles filtrate from primary centrifuge. Value of oil recovered in 1 yr will more than pay for centrifuges. Dewatering and de-oiling of

(Continued on page 68)



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(*Continued from page 66*)

sludge are of value in planning disposal of refinery wastes to keep down size of incinerator. Objectives are to keep phenolic content below avg of 2 ppb and max. of 5 ppb in water, following initial dilution. Apparently, if plant effluents contain less than 20 ppb of phenols, these conditions can be met. pH of effluent is to be maintained between 5.5 and 10.5, and nonvolatile oil content should not exceed 15 ppb.—*PHEA*

Pollution Control. A Symposium. Oil & Gas J., **53**:110 (Aug. 16, '54). **I. Refinery Waste—Stream Survey.** A. P. DENNIS JR. This article is based on survey made for Bayway Refinery of Esso Standard Oil Co. in northern New Jersey, discharging into Arthur Kill, tidal adjunct of New York Harbor. **II. Oil and Sludge Removal at Skelly's El Dorado Plant.** W. L. PURCELL & T. W. FERGUSON. Refinery primary waste-treating facilities, consisting of oil and sludge removal equipment, constitute process separate and distinct from secondary waste-treating facilities, which remove undesirable solutes from waste water. Authors describe in detail procedure recently adopted at refinery of Skelly Oil Co. at El Dorado, Kan., in which wastes were segregated. Current refinery waste water effluent averages about 1,500 gpm (not including sanitary sewage). This is subject to oil removal and secondary treatment. Capacity of oil-water separator was set at 15,000 gpm. Waste water with sludge from water-softening processes is drained to sludge pits, which hold 3–4 months' supply. Batch emulsion-breaking process is operated with heat and demulsifying agents. **III. Chemical Flocculation of Refinery Waste.** R. F. WESTON & R. G. MERMAN. Atlantic Refining Co. operates 10,000-gpd chemical flocculation waste treatment plant at its Philadelphia refinery. This reduces effluent oil content below 30 ppm. Basic treatment includes oil separation, chemical flocculation, sludge dewatering, and sludge incineration. Waste water passes through oil separator to neutralization and flocculating facilities and then to Schuylkill R. Wastes are neutralized by adding slaked-lime slurry and boiler feedwater treatment sludge. Aluminum chloride and alum may be added as coagulants, and activated silica, clay, and lime slurry may be used as coagulant aids. Sludge produced is concentrated and pumped to vacuum filters. Cake is incinerated. This type of plant requires about 3 acres and may cost, exclusive of land, from $2,500,000 to $5,000,000 ('53 basis). Problems of operation and results obtained are given, together with flow diagram.—*PHEA*

Toxicity of Combinations of Certain Inorganic Compounds to *Daphnia magna* L. FREEMAN & I. FOWLER. Sew. Ind. Wastes, **25**:1191 ('53). Standard reference water was substituted for lake or stream water in culturing and testing with *Daphnia magna*. Tests were conducted on 5 inorg. Na salts: bisulfite, carbonate, chromate, silicate, and sulfate. Toxicity thresholds were detd. for these salts individually, in combinations of 2, and in combinations of 3. Results indicate that thresholds are lowest for combinations of 3 and highest for individual compd.—*CA*

Effects of Chemical Compounds on the Survival of Centrarchid Fish. A. W. ANDERSON. Texas J. Sci., 5:449 ('53). Study of 7 wastes from oil fields and chem.

(*Continued on page 70*)

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(*Continued from page 68*)

industry on 5 representative species of centrarchid fish (bass and sunfish) from Texas waters. Tests were of 2 types: with circulating and noncirculating test solns. In first type, to det. wide toxicity limits, two mature individuals of similar size were acclimatized 24 hr in 35-l jars of clean water closely approximating original river water, at DO satn. and 20°–22°. Concn. of compds. was increased every 40 min up to min. lethal dose (MLD) for each species, with test soln. circulated from one jar to another. In second type, to narrow down MLD detns., 4 fishes per jar were acclimatized as above. Various dilns. of noncirculating soln. were then added. Chemicals tested, of technical grade, were: baroid drilling clay, baroid drilling mud, Na tetraphosphate, $Na_6H_2P_8O_{21}$, of low toxicity; NaOH, white lime, and oil well cement, highly toxic. Circulating tests showed higher MLD than noncirculating ones in all cases; 3,000–6,000 against 2,500–4,000 ppm, resp., for low toxic compds., 50–200 against 80–600 ppm, resp., for highly toxic ones. This suggests greater reliability of noncirculating tests due to methods of procedure. Species survival time test with 3,000 ppm of each compd. showed higher resistance of black bass (*Huro salmoides*) and war mouth bass (*Chaenobryttus coronaris*) than of sunfish (*Lepomis*); bass survived 1.5–6 times longer than sunfish. Little difference in survival time occurred between sunfish species.—*CA*

Current Practice in the Treatment of Oil Wastes. K. CASHMORE. Munic. Util. (Can.), **92**:6:32 (Jun. '54). In general, all waste water should be passed through separators. Emulsions must be excluded. Methods for breaking latter include heating to about 180°F, with or without pH adjustment, and flocculation, e.g., with $Fe_2(SO_4)_3$ and lime. Latter will reduce oil content to 2 ppm or less. Spent caustic may be neutralized with spent H_2SO_4 or flue gas, the gases evolved being burned. Treatments for

(*Continued on page 72*)

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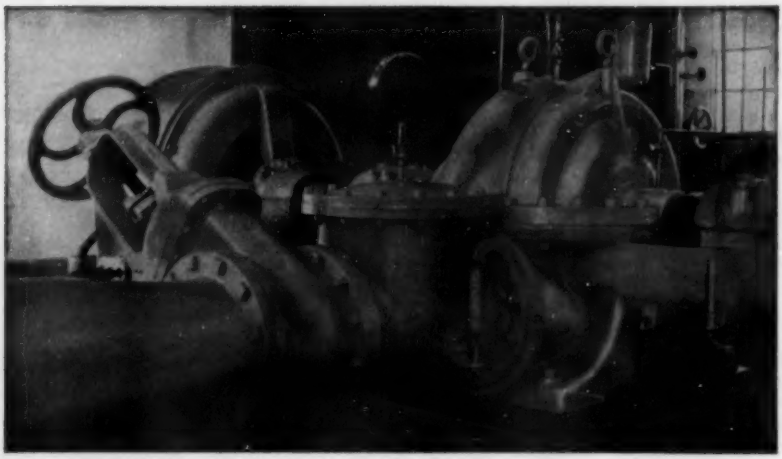

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(*Continued from page 70*)

phenolic wastes include biol. oxidation, O_3, Cl, and ClO_2. Biol. oxidation on trickling filters is cheapest, cultures of required bacteria being obtained from raw water or cultivated soil. Addition of N and P may be necessary.—*R. E. Thompson*

Surface and Underground Disposal of Chemical Wastes at Victoria, Texas. H. O. HENKEL. Sew. Ind. Wastes, **25**:1044 ('53). Article describes waste disposal at du Pont chemical plant. Dilute aqueous solutions are disposed of by solar evaporation. Concentrated aqueous solutions are currently lagooned, but studies have been conducted on pretreatment of sodium chloride brine so that it may be discharged into underground sands at 4,800'. Cooling and storm water is held and tested before discharge to river. Organic liquids are incinerated, as well as waste gases. Organic solids and trash are disposed of in burning pit. Imhoff tank and lagoon are used to treat sanitary wastes. Vegetation, shrimp and oyster population, and biological river surveys are integral part of treatment program.—*PHEA*

AQUATIC ORGANISMS

Effects of Nitrogenous Compounds on Stream Conditions. N. G. FLAIGG & G. W. REID. Sew. Ind. Wastes, **26**:1145 ('54). There was no significant difference in use of inorganic forms of nitrogen by plankton in typical streams having moderate amounts of pollution containing fertilizer elements. Therefore, attempts to control growth of algae in streams receiving sewage effluents by regulation of degree of oxidation are likely to be unsuccessful. Higher concentrations of nitrogen appear to accelerate growth of algae as long as concentrations are not toxic to organisms. This means that organisms may be concentrated in shorter length of stream, when large amounts of nitrogen are present. For this reason, high concentrations of nitrogen may be more damaging than low concentrations. Nitrite form of nitrogen, which appears less efficient as fertilizer in higher concentrations, may easily change into ammoniacal or nitrate form, and become more readily available for plant use. Proteins decompose and become available for plant food if, indeed, they are not already available in their organic forms. This delay may account for lack of algal blooms when wastes are not highly nitrified. Further study should be made of this possibility.—*PHEA*

Toxic Fresh-Water Algae. W. M. INGRAM & G. W. PRESCOTT. Am. Midland Naturalist, **52**:75 (Jul. '54). Outbreaks of human gastroenteritis have not been positively traced to algae. Algae that have been responsible for mammalian, avarian, and fish deaths through some toxic action are all to be found in blue-green algal group, Cyanophyta. Cyanophyta species that have been associated with animal deaths belong in genera: *Microcystis, Aphanizomenon, Anabaena, Nodularia, Coelosphaerium,* and *Gloeotrichia.* Often when deaths of animals occur, wind has been reported blowing, thus tending to concentrate algae in lee shore areas. Cattle that drink only small quantities of water containing *Microcystis* may not die but do show series of illness symptoms, one of which is drop in milk yield. Symptomatic treatment has been recommended by Steyn ('45) for cattle poisoned by algae. Various writers have made reference to several toxic substances associated with blue-green algae. Substances that are toxic enough to cause illness or death in animals are not present in all blue-green algae. Water in which certain blue-green algae have bloomed may produce death in mammals and fish when algal cells themselves are excluded. Toxic material from certain algae may survive laboratory equivalent of water treatment, using alum coagulation, filtration, and chlorination. It may survive activated-carbon treatment in amounts corresponding to that used in water treatment plants.—*PHEA*

Control of Blue-Green Algae Blooms With 2,3-Dichloronaphthoquinone. G. P. FITZGERALD & F. SKOOG. Sew. & Ind. Wastes, **26**:1136 ('54). Large-scale test of effectiveness of 2,3-dichloronaphthoquinone (2,3-CNQ) in controlling excessive growths of blue-green algae has been carried out on Spaulding's Pond, Wis. This 27-acre highly fertile lake normally supports continuous bloom of algae during summer months. Spray applications of 2,3-CNQ suspensions to give overall concentrations from 30 to 55 ppb in lake clumped and effectively killed even heavy growths of blue-green species.

(*Continued on page 74*)

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(*Continued from page 72*)

Chemical treatment had no observable harmful effects on green algae, higher aquatic plants, fish, or zooplankton. In event of rapid recurrence of growth of blue-green algae, repeated applications are necessary. Lasting effect of treatments, however, may be indirectly increased by vigorous growth of green algae and higher aquatics following suppression of blue-greens.—*PHEA*

Practical Method for Control of Algae and Water Weed. A. F. BARTSCH. Pub. Health Rpts., **69**:749 (Aug. '54). Important item in field of water conservation is control of aquatic plants. In addition to insuring availability of water for recreation, fishery management, navigation and other purposes, control of algae and weeds is often necessary for potability. It is possible that cultivated algae may be useful as source of energy-bearing food. Possibility of using algae as raw material for synthetic chemicals also exists. On other hand, excessive algae may cause damage in number of ways, including detrimental effects on filters, tastes and odors, depletion of oxygen, and animal poisoning through toxic action. Control measures include use of chemicals such as copper sulfate in shallow water reservoirs. Primary tests on 2,3-dichloronapthoquinone indicate that it may have much promise. Physical control of water weeds is being accomplished by both mechanical and non-mechanical methods. Breaking, use of chains, cables, use of underwater saws, and similar methods were tried with variable success. Chemicals such as 2,4-D and 2,4,5-T have also been useful.—*PHEA*

Animal Parasites in Sewage and Irrigation Water. W. L. WANG & S. G. DUNLOP. Sew. Ind. Wastes, **26**:1020 ('54). Investigation was made to determine efficiency of primary sewage treatment plus chlorination, as practiced in Denver sewage disposal plant, for removal of animal parasites. Results indicated that about 20% of *Ascaris* ova and 46% of *End. coli* cysts found in raw sewage were still present in final effluent. MPN of coliform organisms and

(*Continued on page 76*)

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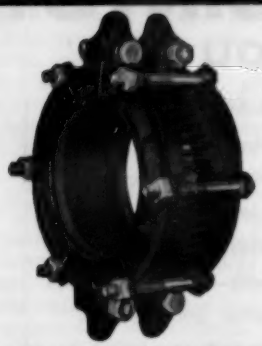

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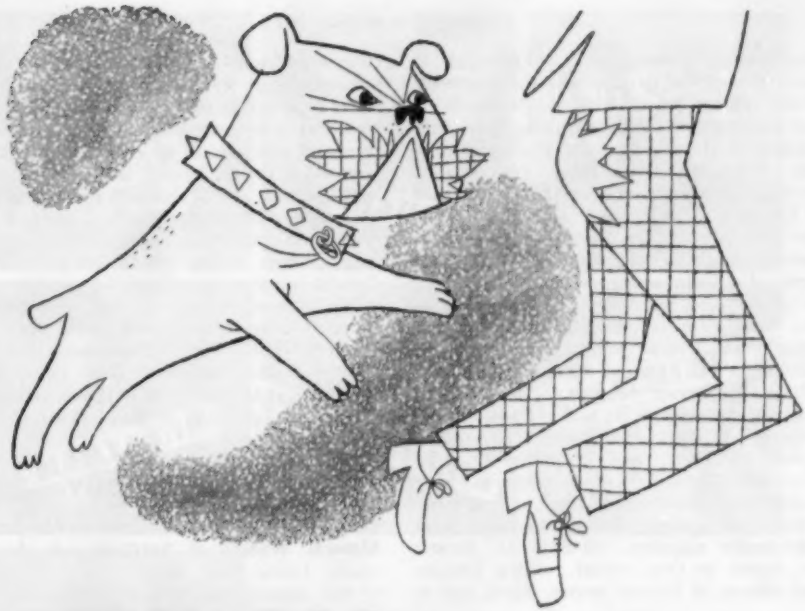

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(*Continued from page 74*)

enterococci, however, showed removal of more than 99% by this sewage treatment. When effluent joined with South Platte R. and flow reached Gardeners' irrigation ditch, number of *Ascaris* ova and *End. coli* cysts was found to be reduced considerably. Average incidence of *Ascaris* ova per liter of Gardeners' ditch water was 1.5 at flume and 1.1 at first farm; for *End. coli* cysts, numbers were 4.7 at flume and 3.6 at first farm. Coliform organisms and enterococci, on other hand, showed higher incidence in this ditch than in effluent. Helminth ova other than *Ascaris* were also found occasionally in raw sewage, settled sewage, and effluent of Denver sewage treatment plant and in South Platte R. below plant. These were ova of hookworm group, *Trichostrongylus, Trichuris,* and *Taenea.* Ova of *Hymenolepsis* and *Trichostrongylus* were found twice in Gardeners' ditch at first farm. Efforts to recover *End. histolytica* were consistently negative. 81–88% of *Ascaris* ova found in raw sewage, settled sewage, and effluent of Denver sewage plant, and in river water and Gardeners' ditch water containing sewage effluent, were viable. Incidence of helminth ova in vegetable washings was also investigated. One sample of lettuce and one sample of cabbage, out of 7 samples of celery, lettuce, and cabbage collected during period sewage plant was inoperative, showed *Ascaris* ova, whereas 15 samples of lettuce, cabbage, and celery collected when sewage was being treated showed negative results. 13 samples of celery, carrots, onions, cabbage, and lettuce collected from Clear Creek area were all negative. Public health significance of these findings is discussed, but definite conclusions cannot be stated, as little is known of minimum infecting doses of these organisms.—*PHEA*

BACTERIOLOGY

Survival Time of *Escherichia coli* in Some Mineral Waters of Sardinia. B. Angelillo. Igiene Mod., 46:623 ('53). Purpose of this investigation was to establish more

(*Continued on page 80*)

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ELECTRIC PHOTOMETER

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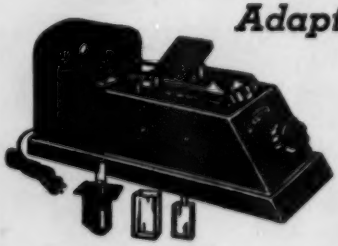


Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

KLETT MANUFACTURING CO.
179 EAST 87th STREET • NEW YORK, N. Y.

Universal in name... service... usefulness...

If you took a poll of the chemical feeders in water works service throughout the country, you would have dramatic proof of the popularity of Omega Universal Feeders. Here are a few of the hundreds of Universal Feeders which, today, are solving the chemical feeding problems of cities and towns in every state of the Union.

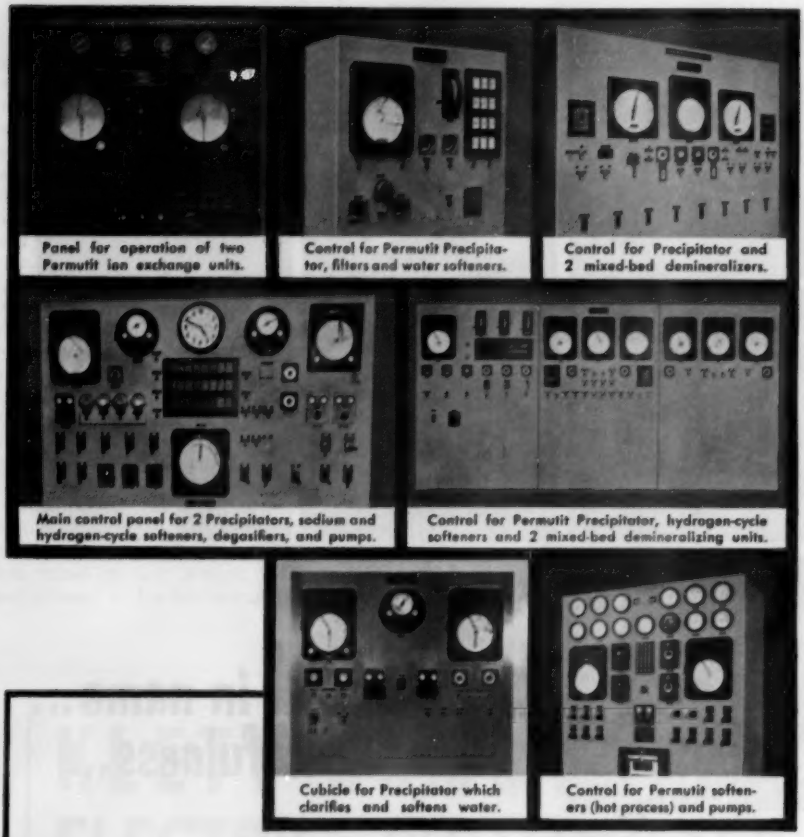
Are you acquainted with the many features of Omega Universal Feeders? If not, write for Bulletin 20-J10A. Omega Machine Company, 365 Harris Ave., Providence 1, Rhode Island.

OMEGA *THE LAST WORD IN* FEEDERS

DIVISION OF B-I-F INDUSTRIES, INC.

BUILDERS IRON FOUNDRY • PROPORTIONEERS, INC • BUILDERS-PROVIDENCE, INC.

METERS FEEDERS CONTROLS



Panel for operation of two Permutit ion exchange units.

Control for Permutit Precipitator, filters and water softeners.

Control for Precipitator and 2 mixed-bed demineralizers.

Main control panel for 2 Precipitators, sodium and hydrogen-cycle softeners, degasifiers, and pumps.

Control for Permutit Precipitator, hydrogen-cycle softeners and 2 mixed-bed demineralizing units.

Cubicle for Precipitator which clarifies and softens water.

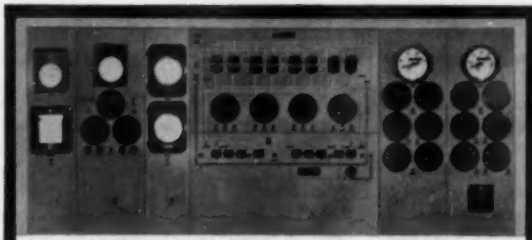
Control for Permutit softeners (hot process) and pumps.

Why we make

Life might be simpler if we "farmed out" our control cubicles and instrument panels . . . but we like to build *every* major component of a PERMUTIT water-conditioning or ion exchange system . . . so that we know it will do its specific job properly.

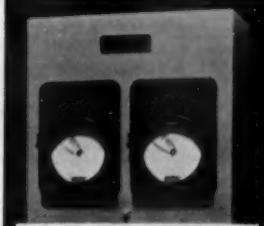
That's why these panels . . . and the hundreds of others in power plants, chemical process plants, manufacturing plants and municipal water works . . . are designed by Permutit engineers and assembled, wired and piped in Permutit factories.

That's why we design and build our own special parts such as multiport valves, strainer systems and

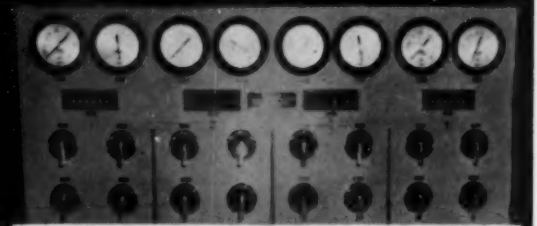


Graphic control for eight Permutit ion exchange units for demineralizing sugar solutions in a large refinery.

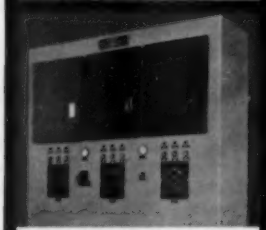
Control for Permutit two-step demineralizing equipment.



Control for Permutit softening equipment (hot-process).



Permutit control panel for four gravity filters installed at the new generating station of a large eastern utility.



Panel for operation of three mixed-bed demineralizers.

Alarm system for Permutit two-step demineralizers.

our own panels:

chemical feeders. That's why we make our own ion exchange resins.

As a result, we talk in terms of over-all results. And you get *complete* service from *one* source.

For further information, write to: The Permutit Company, Dept. JA-4, 330 West 42nd St., New York 36, New York.

WATER CONDITIONING • ION EXCHANGE

PERMUTIT®

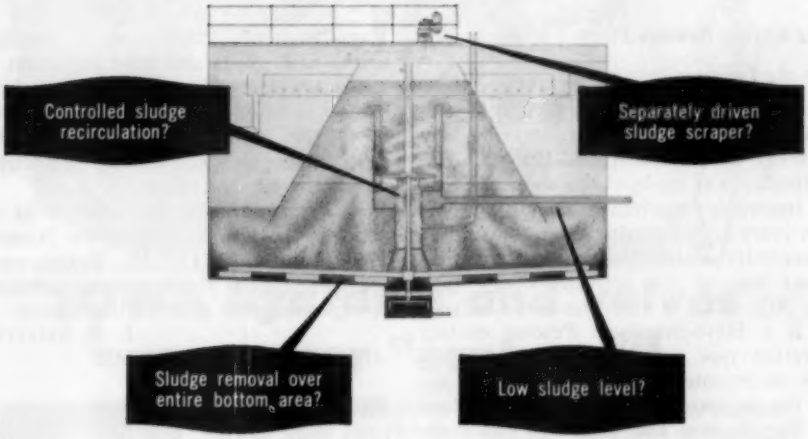
(Continued from page 76)

reliable sanitary control of mineral waters in respect to *Esch. coli* (I). 2 Sardinian mineral waters of alk. bicarbonate type (San Martino and Montes), which had been bottled day before, were treated with suitable suspension of I. Each sample was kept at room temp. and at cold-room temp. in absence of light. Assays were done each day for first 10 days and at 5-day intervals thereafter by agar (Drigalski) and Smith's broth methods. Results of assays on 35 ml of contaminated water showed I survival period of 20 days at cold temp. and 28 days at room temp. As mineral waters differ in autosterilizing power, depending on their phys. and chem. character, it becomes necessary to measure this power for each one for reliable sanitary control.—*CA*

Survival of *Esch. coli* in Water From Great Salt Lake. R. S. FRASER & C. I. ARGALL. Sew. Ind. Wastes, **26**:1141 ('54). Contrary to previous assumptions, *Esch. coli* is not killed rapidly by water from Great Salt Lake. At summer temperatures few bacteria will survive more than 8 hr, but at 6°C approximately 50% will survive 24-hr exposure to lake water. Membrane filter technique proved valuable in testing survival of bacteria in unfavorable environment and has provided excellent means for transferring organisms from unfavorable environment to one that is favorable.—*PHEA*

The Choice of an Indicator Organism for the Bacteriological Control of Swimming Bath Purification. PUBLIC HEALTH LAB. SERVICE WATER SUBCOMMITTEE. Monthly Bul., Min. of Health & Pub. Health Lab. Service (Br.), **12**:254 (Dec. '53). Coliform test is widely accepted for assessing potability of water, and use of *Esch. coli* as indicator organism to assess effectiveness of water purif. is well established. Water of swimming pool, however, is exposed to contamn. not only from intestine but also from mucous surfaces (e.g., nasopharynx) and from body surface itself. There have been conflicting opinions on most suitable organism to use as indicator for bact. control of swimming pool purif.; it was, therefore, decided to undertake investigation into this matter. This study was limited to pools in which process of continuous circulation, filtration and chlorination was in operation so that there could be no doubt of eff. of purif. processes. Samples were examd. for presence of coliform organisms, hemolytic streptococci, staphylococci, and *Neisseria catarrhalis*, as well as for general bact. cleanliness, by means of plate count. Free and total residual chlorine contents and pH of water were measured at time of sampling. As preliminary expt, and in order to appreciate degree of bact. poln. in pool, examns. were made of water after 74 male bathers had been in it during previous 2 hr, water being circulated and filtered, but not chlorinated. Considerable numbers of bacteria of all types were present, as shown by plate counts at 37°C and 22°C. Conventional bact. indicators of intestinal poln. were present, but only in small numbers. Staphylococci were numerous and *Neisseria catarrhalis* was very numerous, many organisms being present in 0.5 ml of sample. Then 178 samples (72 from inlets and 106 from outlets of pools) were collected from 37 pools in 5 localities and examd. at nearby labs. in Birkenhead, Conway, London, Manchester, and Oxford. Coliform organisms and *Neisseria catarrhalis* were seldom isolated from samples in which free residual chlorine exceeded 0.1 ppm. Alpha-hemolytic streptococci and staphylococci were too resistant to chlorination to be of much service as indicator organisms. Plate counts in nutrient agar at 37°C and 22°C showed close correlation with levels of free residual chlorine. Of 138 samples in which free residual chlorine exceeded 0.1 ppm, plate count at 37°C did not exceed 10 colonies per ml in 76.1% or 100 colonies per ml in 95.7%. Corresponding percentages for plate counts at 22°C were 79.0 and 93.5. Bathing loads appeared to have little effect in increasing bact. poln. of water, and, on occasions when paired samples were taken from inlet and outlet of bath, there was no appreciable difference in bact. qual. of 2 samples. As recommended std. for swimming pool water, it is suggested that no sample examd. should contain any coliform organisms in 100 ml and that in 75% of samples examd. plate count at 37°C from 1 ml of water should not exceed 10 colonies, nor 100 colonies in remainder. It is possible to maint. pool water at this std. with free residual chlorine as low as 0.1 ppm, but this level allows no margin of safety and is, in practice, difficult to maint. Level of 0.2–0.5 ppm recommended by Min. of Health should maint. swimming pool water in bacteriologically satisfactory condition, provided that chlorine is present as free residual chlorine. —*BH*

WHICH FEATURES...
ASSURE THE CLEAREST WATER?


Controlled sludge recirculation?
Separately driven sludge scraper?
Sludge removal over entire bottom area?
Low sludge level?

They all help to produce clear water. But only when all four features are combined in a single unit can you be sure of a dependable and economical supply of clear water at all times. The GRAVER REACTIVATOR®, a cold process softener and clarifier, is designed to combine all these features. Forty-five years of water conditioning experience have gone into this design — a design that has a proven, successful performance record in hundreds of installations.

WRITE FOR DESCRIPTIVE CATALOGUE WC-103A

Municipal Department: M-112

GRAVER

GRAVER WATER CONDITIONING CO.
A Division of Graver Tank & Mfg. Co., Inc.
216 West 14th Street, New York 11, N. Y.

Correspondence

Big Spring Sewage Plant

To the Editor:

In the article, "Industrial Use of Reclaimed Sewage Water at Amarillo," by Marvin C. Nichols (Jan. 1955, p. 29), reference was made to the successful use of treated sewage effluent during the past ten years at Big Spring, Tex., but it was incorrectly stated that the Big Spring plant was of the activated-sludge type (p. 30). This is a serious error because it is a Hays-Schulhoff Process contact aeration type sewage treatment plant—not an activated-sludge plant. I was one of the engineers who designed the plant at Big Spring, and, after we had made a thorough study of the individual characteristics of several other types of treatment, we chose the Hays-Schulhoff type because we were convinced that it could be depended upon to give the continuous treatment necessary under the contract. Operative experience at Big Spring during the past ten years has proved that this type of treatment plant could deliver a high quality of effluent at all times; therefore, our choice of treatment was sound.

It seems to me very important that the error in the article should be called to the attention of the readers of the JOURNAL. Engineers should know that the Big Spring plant is a Hays-Schulhoff contact aeration type, and that the soundness of the undertaking was due to the efficiency and economy of this particular type of plant. It might also be of interest to readers to learn that Big Spring has recently doubled the size of its installation by the addition of another Hays-Schulhoff Process plant, identical to the first. It is also most important to stress the fact that the Hays-Schulhoff contact aeration type of sewage treatment is capable of providing effluent for industrial use, and thereby to help dispel any notions to the contrary.

Interested readers are referred to an article by N. T. Veatch in the January 1948 JOURNAL (p. 1). Mr. Veatch made special mention of the contact aeration sewage treatment plant at Big Spring.

L. B. GRIFFITH

Arlington, Va.; Feb. 16, 1955

Silica Sols

To the Editor:

I have read with a great amount of interest the paper by L. L. Klinger on "Experience With Activated-Silica Treatment" (Feb. 1955, p. 175). The author makes the statement: "Baylis was the first of many investigators to patent a silica sol." This statement is not in accordance with the facts. I refer you to the Graf-Schworm patent (2,234,285) application Serial No. 134,372, dated Apr. 2, 1937, and the Baylis patent (2,217,466) application Serial No. 164,372, dated Sep. 17, 1937. You will note our priority of six months.

These two applications were so close together that the examiner cited mutual interference, resulting in a friendly settlement of claims between Baylis and ourselves. C. A. Black, in his article, "Activation of Silica for Use in Water Treatment" (Oct. 1953 JOURNAL, p. 1101), was aware of this when he said: "The work was done independently and concurrently

(*Continued on page 84 P&R*)

Proud "city fathers" must look to the future, too!

IOWA hydrants and valves are never "orphans"!

No need to worry about the future of your city's water system when you choose *Iowa*. You know you're buying a reliable product from a reliable firm and that there will always be replacement parts, when and as needed. What you may not know, though, is this . . . *Iowa* hydrants are easily and economically serviced—even by new employees without special training.

Below are additional facts to keep in mind when you plan to expand or replace any part of your city water works.

IOWA HYDRANTS	IOWA GATE VALVES
Provide full, truly unrestricted water way.	Double disc, parallel seat.
Open *with* the pressure for faster water delivery.	Positive wedging action for efficient, no-leak closing.
Close *against* the pressure to eliminate water hammer, provide flushing action.	Gates hung loosely from stem nut—no binding.
Assure positive drainage.	Rugged, time-proved design means long life, low service costs.
Are available for any type of connection.	Available with bell, flange, or mechanical joint connections to fit any existing or planned installation.
All working parts removable through top—no digging or special tools required.	
Meet all A.W.W.A. specifications.	Meet all A.W.W.A. specifications.

The best insurance policy is the order that specifies IOWA!

IOWA VALVE COMPANY
A Subsidiary of James B. Clow & Sons

Oskaloosa, Iowa

DRILL WITH SPINKS

FOR HIGHER CAPACITY WELLS

SPECIAL MUDS MINED AND PROCESSED FOR WATER WELL DRILLING!

- **SPINKS Gleason**—easy-mixing mud, washes out quickly, easily. Minimum penetration! Makes heavy mud — 9.5-lb. to 10-lb. range — stops cave-ins! Excellent lubrication properties! Removes cuttings quickly, thoroughly! Durably sacked in water-repellent asphalt lined bags! 50-lb. size for easy handling . . . less chance of loss!
- **SPINK-Gel** — high-yielding, finest quality Wyoming bentonite. Low water loss! Exceptional lubricating qualities!
- **SPINK-O** — medium weight mud. Combines outstanding qualities of Gleason and Spink-Gel.

Distributorships now open in several choice territories! WRITE, WIRE or CALL Rich Carothers. Telephone 1502, Paris, Tenn.

H. C. SPINKS CLAY COMPANY, INC.
Mines and General Offices
Paris, Tennessee

Spinks

Correspondence

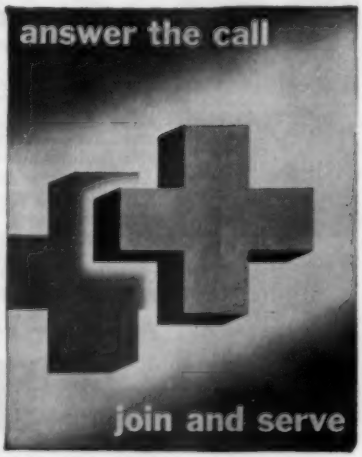
(*Continued from page 82 P&R*)

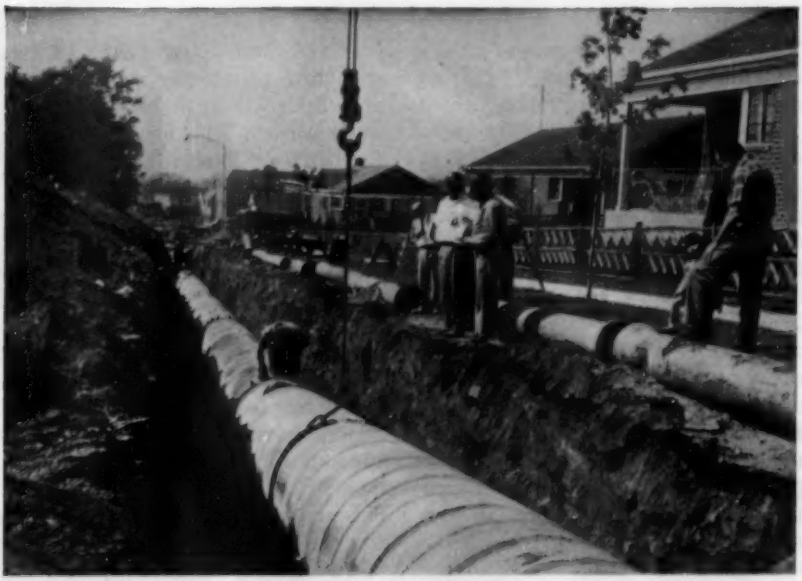
by J. R. Baylis at Chicago and by Graf and Schworm at St. Louis." Also, Merrill and Bolton (Jan. 1947 *Chemical Engineering Progress*, "Activated Silica, a New Chemical Engineering Tool") say (p. 27): "The first successful efforts to use silica sols in water coagulation on a large scale were made about ten years ago by J. R. Baylis at Chicago and by Graf and Schworm at St. Louis. The two attacks on the problem were made independently and at about the same time." Much later (Feb. 1943), Baker and Dedrick modified our process and were able to obtain patent No. 2,310,009 covering their modification.

We have reason to believe that our laboratory research antedated the work of Baylis by several years, but this is not the point at issue. We feel that authors and editors of papers involving the research of other men should carefully check their statements to preclude the dissemination of information which is either erroneous or misleading.

WILLIAM B. SCHWORM

St. Louis, Mo.; Feb. 24, 1955





Long string of 48-in. pipe being laid on 73d Ave., bordering Alley Park. The small-diameter pipe is for local feed only.

6-Mile Tar-Enameled Steel Water Main Under Way in Fast-Growing Queens, N. Y.

Few areas in the land have grown as fast as the Borough of Queens, New York City, which occupies the entire northwest section of Long Island. To keep pace with the resulting vastly increased water demands, the Bureau of Water Supply of the Department of Water Supply, Gas and Electricity is expanding its water supply system.

A major project which got under way in 1954 extends one of the Queens trunk mains eastward from Main Street in Flushing six miles to the Douglaston Pumping Station, and provides for future development in the Floral Park area.

The new main consists of Bethlehem Tar-Enameled Steel Pipe of large diameters: 20,350 feet is 60 in. ID; 8,080 feet is 48 in. ID; and 2,860 feet is 36 in. ID. The pipe, in 40-ft lengths, was hydrostatically tested, coal-tar enameled inside and out, wrapped and drilled for riveting at Bethlehem's Steelton, Pa., pipe shop. Bethlehem also supplied numerous bends, reducers and other pipe specials. Contractor for installation of the line was Tibbetts Contracting Corp. of Yonkers.

When you're planning your next water or sewage line, the wisest move you could make would be to pick up your phone and dial the nearest Bethlehem district sales office. We will be happy to give you detailed information about Bethlehem Tar-Enameled Steel Pipe.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM *Tar-Enameled* STEEL PIPE

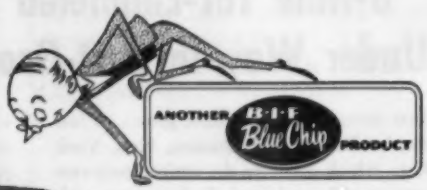
(Continued from page 52 P&R)

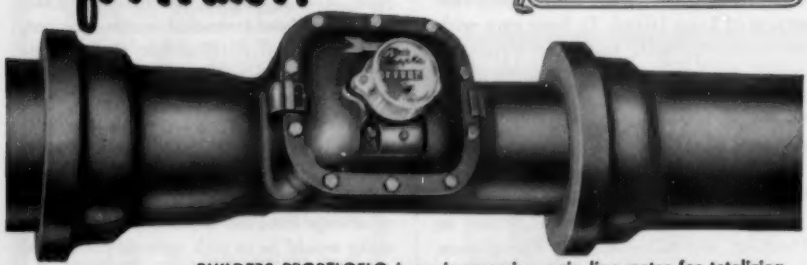
Taps for 160,000,000 people sounds a little too much like a headline for an H-bomb story, but we're talking about the location of the 1,000,000,000 washers in the United States—faucet washers, that is. What made us washerwise was a query from one of our Canadian friends concerning the number of washers used per capita per year. A horseback questionnaire around the office indicated a total of 5 taps per person and a washer life of 2 years, which checked out exactly with the Canadian count independently tallied. The billion then emerges by adjusting somewhat down for the older homes or bigger families and considerably up for hotels and public, commercial, and industrial buildings. All of which is to say 500,000,000 washer changes per year and, even leaning over backward enough to count only about a week of drip before that, at least 5 bil gal of water waste. Taps for drips from taps is what we'd like to headline.

Jobs! Jobs! Jobs! There seem to be more good ones floating around these days than there are qualified water works men to fill them. So if you're on the loose or on the prowl, you'll do well to record your interest with AWWA. Send along a resume that includes personal data, a record of your education and experience, and an indication of your preference in type of work and location. Two or three copies will be that much better, and a recent photo attached to each is recommended to cushion the later

(Continued on page 88 P&R)

What a Meter for Water!





BUILDERS PROPELOFLO is an inexpensive main line meter for totalizing water consumption. Gives dependable, trouble-free service on the job. Meters accurately over wide range — six-digit totalizer shows water use directly in gallons, cubic feet, etc. For complete information on this easy-to-install meter, write to Builders-Providence, Inc., 365 Harris Ave., Providence 1, Rhode Island.

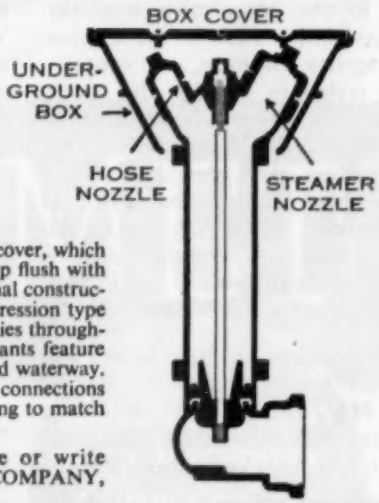
BUILDERS-PROVIDENCE

DIVISION OF B-I-F INDUSTRIES, INC.

BUILDERS IRON FOUNDRY • PROPORTIONEERS, INC. • OMEGA MACHINE CO.

METERS FEEDERS CONTROLS

This M & H Hydrant sets completely underground. The cast iron box cover is on line with the ground level, thus completely eliminating any interference with traffic. M & H flush type hydrants are especially designed for use at airports servicing the heaviest modern airplanes.



The operating nut and nozzles are accessible simply by lifting the two piece cover, which has disappearing handles designed to drop flush with the cover when not in use. Hydrant internal construction is exactly the same as M & H compression type fire hydrants used by so many municipalities throughout the country. M & H flush type hydrants feature a 5¼" valve opening and an unobstructed waterway. Can be supplied with one or two fire hose connections and/or with steamer nozzle, with threading to match existing standards.

For additional information, wire or write M & H VALVE AND FITTINGS COMPANY, ANNISTON, ALABAMA.

M&H PRODUCTS FOR WATER WORKS • FILTER PLANTS INDUSTRY • SEWAGE DISPOSAL AND FIRE PROTECTION

(Continued from page 86 P&R)

Lloyd Logsdon (center), retiring vice-president and general manager of the Mueller Co. West Coast sales and plant operations in Los Angeles, was honored by the company at a testimonial dinner on Feb. 5. Shown with Mr. Logsdon are William H. Hipsher (left), executive vice-president of the firm, and Robert H. Morris, vice-president and general manager.

shock to the prospective employer. The Association isn't in the employment agency business, of course—merely trying to see that the opportunities about which it hears knock on the doors of AWWA members. Your door numbers, then, should be sent to "Employment Information File" at headquarters. AWWA will do its best to do the rest, with the help, naturally, of those who remember to put in their call for: Men! Men! Men!

Ross J. Burns has been named water meter sales manager for Badger Meter Mfg. Co., at Milwaukee, Wis. Replacing him as western sales manager, at Los Angeles, is John Way.

William T. Field, consulting engineer of Watertown, N.Y., was honored as the north country's "Engineer of the Year," at the annual dinner of the Jefferson-Lewis chapter of the New York Society of Professional Engineers on Feb. 22. Mr. Field, a Life Member of AWWA (which he joined in 1910), has long been an energetic and persistent worker on behalf of public projects, such as the Thousand Islands Bridge and the St. Lawrence seaway.

Martin F. Wilkerson, a member of the Diamond Alkali Co. sales staff since 1948, has been appointed manager of the company's branch sales office at Houston, Tex.

Philip J. O'Connor, chief chemist and superintendent of the filtration plant at Warren, Ohio, died suddenly, of a heart attack, at his home on Feb. 14. Mr. O'Connor, 58, had been an AWWA member since 1922 and had served with the Warren water department since its inception in 1919.

(Continued on page 90 P&R)

"THE METER YOU CAN COUNT ON"

Simple Design...

Quick Repairs....

Easy Disassembly...

Rugged Construction..

CALMET

MANUFACTURED BY
WELL MACHINERY
& SUPPLY CO., Inc.,
FORT WORTH, TEXAS

(Continued from page 88 P&R)

Science it is that is making neurotics of us all. And who can be blamed for neurotting a little when day by day his best-founded beliefs are being scientifically cut out from under him? Latest of these sacrifices to scientific methodism seems to be the "common knowledge" that it is the water stored in his hump that permits the camel to go for so long without a drink. As a matter of fact, most of the non-Egyptologists among our small fry would give you pretty good odds that the hump decreased in size as the camel drew on it during his travel across the desert, thus making these elevated tanks not only portable but self-adjusting.

Now the Drs. Schmidt-Nielsen, husband and wife zoologists of Duke University, would have us know that this long-accepted concept is strictly at variance with the facts. Having led a UNESCO research team that made an intensive study of the camel in his native habitat, even to the extent of subjecting him to basal metabolism tests, the Schmidts point out that his thirst control is all a matter of perspiration. One of their test animals, fed only hay and dried dates for 17 days, during which time he was often in the scorching sun when the temperature was well over 100°F, lost only a third of his body weight during that period and was able, with no ill effects, to suck up 20 gal of water in a few minutes at the end of it. "The camel," they report, "begins sweating only after a considerable increase in body tempera-

(Continued on page 92 P&R)

AA QUALITY

For Public Water Fluoridation

Sodium Silicofluoride—98%

(Dense Powder)

Sodium Fluoride—98%

(Dense Powder or Granular)

Meets AWWA specifications

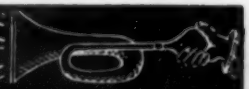
White or tinted blue
Minimum of dust in handling
Minimum of storage space

Available in bags and drums

The AMERICAN AGRICULTURAL CHEMICAL Co.

50 Church Street, New York 7, N. Y.

YOU WERE DOING THIS



WHEN THE FIRST HYDRO-TITE JOINTS

WERE BEING POURED -

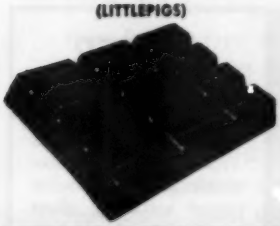
HYDRO-TITE (POWDER)

HYDRO-TITE

(POWDER)

For over 40 years HYDRO-TITE has been faithfully serving water works men everywhere. Self-caulking, self-sealing, easy-to-use. Costs about 1/5 as much as lead joints. Packed in 100 lb. moisture-proof bags.

HYDRO-TITE (LITTLEPIGS)



HYDRO-TITE

(LITTLEPIGS)

The same dependable compound in solid form —packed in 50 lb. cartons—2 litters of pigs to the box—24 easy-to-handle Littlepigs. Easier to ship, handle and store.

FIBREX (REELS)

FIBREX

(REELS)

The sanitary, bacteria-free joint packing. Easier to use than jute and costs about half as much. Insures sterile mains and tight joints.

HYDRO-TITE

HYDRAULIC DEVELOPMENT CORPORATION

(Continued from page 90 P&R)

ture and even then does not drip with perspiration."

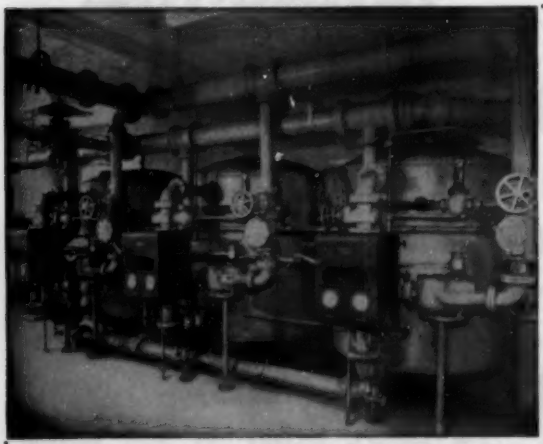
Anyway, if our deodorant ads are to be believed, all this is sure to make camels nice to be near. Tunis anyone?

Folding steel barricades, 4–10 ft in length, are being marketed by the All-Craft Mfg. Co., Butler, Wis. Steel legs, which lock when open, can be folded into the heavy-gage steel top members to provide compact, easily handled units. The cost is said to be competitive with that of wooden barricades.

R. W. Pearce, manager of chlorinizer sales, has been made works manager of B-I-F Industries, Inc. The position was vacant for almost a year, when Earl H. Bradley left the post to become president of the firm. Pearce has been with the B-I-F organization since 1936, and has served in a wide range of production and management positions.

John M. Maitland has been appointed manager of the Detroit district office of the Bristol Co. He had been with the company's New York office since 1953.

Relly S. Clark has been appointed Warren Foundry & Pipe Corp. sales representative in the New York State area, with headquarters in a new branch office at Avon, N.Y. Mr. Clark has held the position of superintendent of water for the village of Avon, and headed the water works sales department of Haverstick & Co., Rochester, N.Y.



WATER PROBLEM?

Photo on left shows a typical H & T fully automatic, municipal, zeolite water softening plant producing clear, iron free, soft water.

Operation of this automatic water treatment plant is by our electrically operated *poppet* type multiport valves—the valves which provide unequalled performance.

If you have a water problem of any size or type—write us. With over 50 years of experience—conditioning water—We Can Help You

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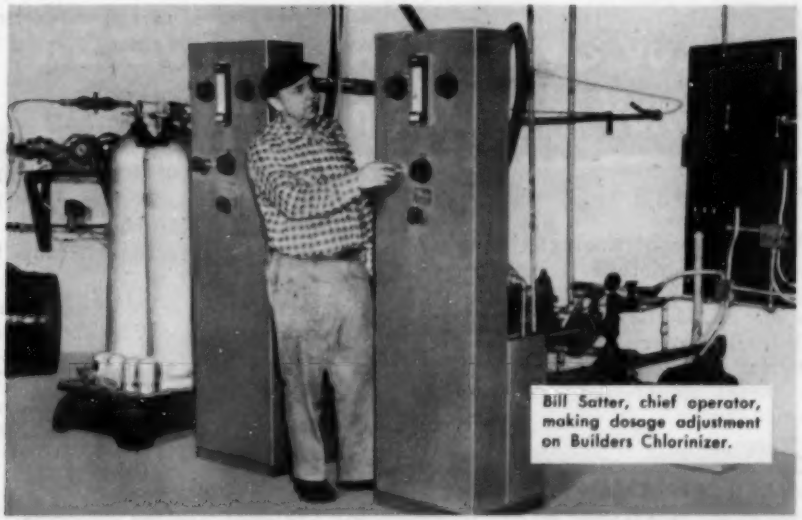

Bill Satter, chief operator, making dosage adjustment on Builders Chlorinizer.

CHLORINIZERS . . . Public Health Defenders at Grand Haven, Michigan

Grand Haven (population 10,000) gets its municipal water from three Ranney type wells located just off the shore in Lake Michigan. Water drawn from these wells is chlorinated by two Model DVS-A Builders Chlorinizers, and then pumped directly into the main which supplies the city.

Mr. R. V. Terrill, City Mgr. says: "Because these feeders are so easily adapted to automatic-proportional pacing from a propeller-type meter, initial and installation costs proved considerably lower than they would have been with any other type of chlorine gas feeder. Performance of the Chlorinizers has been excellent. I checked the records the other day and found we haven't spent a cent for repairs or service since these chlorine gas feeders were installed in January 1952."

Hundreds of cities throughout the country are selecting Chlorinizer . . . . for replacement, for plant expansion, for new projects. For Bulletins 840-F1B, 840-J30 and 840-J8 giving complete information, write Builders-Providence, Inc., 365 Harris Ave., Providence 1, R. I.

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BIF METERS FEEDERS CONTROLS

Service Lines

Automatic proportioning of Builders-Providence chlorinizers is described in Sup. Bul. 840-K13, obtainable from the company at 345 Harris Ave., Providence 1, R.I. The system is called "flow responsive," because it converts flow values into output air pressures required for chlorine feed.

Cleaning of pressure filter media in place by the use of a solvent wash is discussed in an issue of the Dowell Service Bulletin entitled "Preventive Maintenance Cuts Replacement Costs." Requests should be addressed to Dowell Inc., Box 536, Tulsa 1, Okla.

Horizontal split-case, double-suction centrifugal pumps are the subject of Bul. 105-B on Type 0 pumps, available from Aurora Pump Div., New York Air Brake Co., 629 Loucks St., Aurora, Ill.

Double-cushioned electric check valves are the subject of Bul. W-10 of Golden-Anderson Valve Specialty Co., 1221 Ridge Ave., Pittsburgh 33, Pa. The valve is designed as part of the electric circuit controlling the pump, in order to eliminate shock and water hammer.

Instant mixing in the pipeline is offered by the American Well Works Homomix, as described in Bul. 300 of the American Well Works, Aurora, Ill. The device utilizes a diffusing impeller to blend chemicals uniformly and rapidly.

Submersible pumps of Pleuger Submersibles Eng. & Mfg. Co., 959 Harrisburg Ave., Lancaster, Pa., are described in a 24-page catalog just issued. The pump uses a water-filled and water-lubricated motor, requiring no seal or stuffing box.

MF characteristics and application details as discussed in over 80 technical articles are reviewed and summarized in a 36-page booklet entitled "MF Millipore Filters." Distributed by Millipore Filter Corp., Watertown 72, Mass., the booklet is fully illustrated and includes several full-color photographs of *E. coli, S. typhosa* and other bacterial colonies cultured on the molecular filter membranes. A section on media formulations is included, together with the complete bibliography of the technical literature upon which the booklet is based. In addition to its bacteriological applications, the MF has been used for dust and other sus-

(Continued on page 96 P&R)

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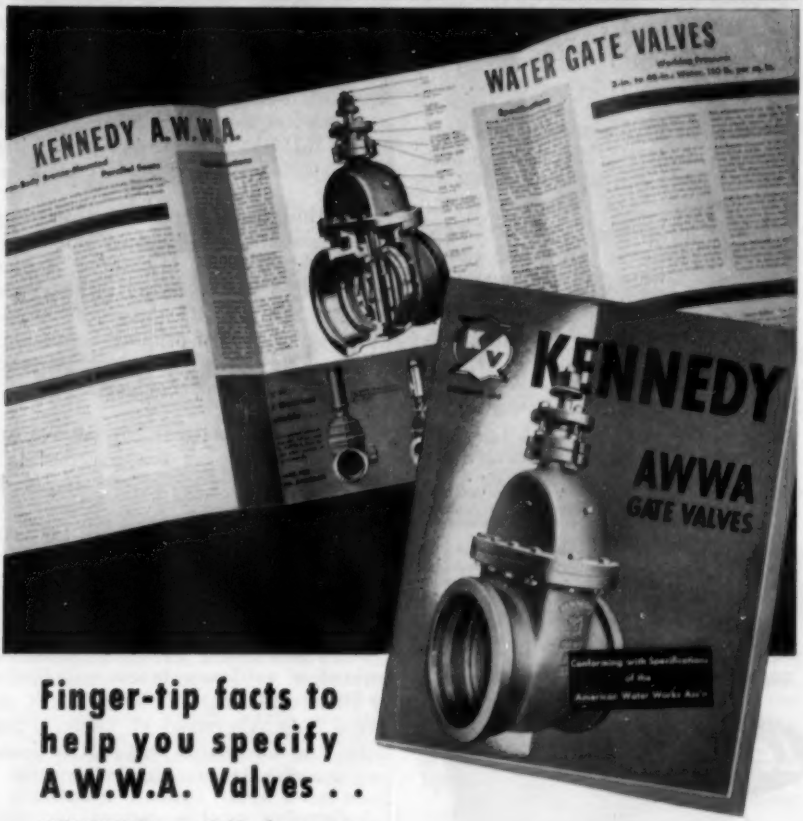

Finger-tip facts to help you specify A.W.W.A. Valves . .

KENNEDY has available for you now, a bulletin with complete information on the Kennedy line of A. W. W. A. Gate Valves. You'll find detailed specifications including lists of the wide range of types, sizes, controls, accessories plus connections and gearing arrangements available. Here's excellent reference material combined with important facts you need when ordering or specifying A. W. W. A. Valves. Get your free copy now!

• *Write for Bulletin 106*

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Service Lines

(Continued from page 94 P&R)

pended solids sampling, selective filtration of dispersions, and chemical analyses.

Diatomite filter operation is the subject of a 4-page booklet, Bul. 5502, distributed by General Filter Co., Box 111, Ames, Iowa.

Parallel-shaft gear drives in 39 standard sizes are described in a 32-page bulletin, No. 2619, issued by Link-Belt Co., 307 N. Michigan Ave., Chicago 1, Ill. The publication contains complete engineering data, including simplified horsepower tables, dimensions, and overhung load capacities.

Basic telemetering equipment is covered in an 8-page bulletin, No. 9100, available from Automatic Control Co., 995 University Ave., St. Paul 4, Minn. The proportional-multiple model permits up to 29 signals to be transmitted in both directions, without regard to sequence.

The second edition of the Reilly Tar & Chemical Corp. "Chemical Index," an 8-page booklet, contains information on over 100 compounds, including thirteen chemicals not listed in the previous edition. Copies are available from the company, 1615 Merchants Bank Building, Indianapolis 4, Ind., or its district offices.

Worthington Corp., Harrison, N.J., has released two 8-page bulletins: No. S-500-B52B covers DR diesel engines and includes rating charts and fuel cost curves; No. 1230-B1 describes contractors' portable self-priming centrifugal pumps, with details on construction, specifications, and component parts.

Liquid-level measurement, control, and transmission systems are described in a 20-page bulletin, No. 1161, issued by Minneapolis-Honeywell Regulator Co., Industrial Div., Philadelphia 44, Pa. Applications, principles of operation, limitations, and advantages of different types of systems are discussed.

Soda ash slurry storage systems are covered in a 16-page brochure published by Diamond Alkali Co., 300 Union Commerce Bldg., Cleveland 14, Ohio. Pneumatic and mechanical methods of handling are also described and illustrated.

Swimming pool equipment, including filters, chemical feeders, pumps, and accessories, is described in Bul. WC-109 (12 pages), issued by Graver Water Conditioning Co., 216 W. 14th St., New York 11, N.Y.

A spring action swing check valve, said to avoid slamming and to offer minimum resistance to flow, is described in a pamphlet issued by the W. R. Ames Co., 150 Hooper St., San Francisco, Calif. The valve has a working-pressure rating up to 150 psi and is available in 4-, 6-, and 8-in. diameters.

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Note that there is no sign of rust or tuberculation. Brush marks are still visible. The original coefficient of flow has been maintained over the years. With such performance available from Bitumastic Enamel, there is no need to specify over-sized diameter pipe, thus giving important installation as well as operational economies.

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CHANGES IN MEMBERSHIP

NEW MEMBERS

Applications received Feb. 1–28, 1955

Adkins, Ralph W., Asst. Supt., Water Dept., Colorado Fuel & Iron Corp., Box 316, Pueblo, Colo. (Jan. '55) *MRPD*

Al-Ani, Najmiddin A., Graduate Student, San. Eng., State Univ. of Iowa, 411 S. Dubuque, Iowa City, Iowa (Jr. M. Jan. '55) *P*

Allen, George H., Supt., Light & Water Dept., Ord, Neb. (Jan. '55) *MRPD*

Baltimore City Health Dept., San. Sec., George W. Schucker, Director, Municipal Office Bldg., Baltimore 2, Md. (Corp. M. Jan. '55) *RPD*

Beaven, Thomas M., Personnel Director, Indianapolis Water Co., 113 Monument Circle, Indianapolis 6, Ind. (Jan. '55) *M*

Bechard, Laurent, San. Inspector, Prescott & Russell Health Unit, Casselman, Ont. (Jan. '55)

Bennett, A. L., Eng. Div., State Health Dept., Des Moines 19, Iowa (Jan. '55)

Bevan, R. D., Tech. Service Supervisor, Canadian Industries (1954) Ltd., Box 10, Montreal, Que. (Jan. '55) *P*

Beyersdorf, Herbert, Sales Repr., Dearborn Chem. Co., 1709 Crescent St., Franklin, Ind. (Jan. '55) *P*

Bodnar, Steven A.; *see* Kraft Foods Co.

Booker, R. W., & Assocs., Cons. Engrs., Ralph W. Booker, 1722 Olive St., St. Louis 3, Mo. (Corp. M. Jan. '55)

Booker, Ralph W.; *see* Booker, R. W., & Assocs.

Bouchard, Jean-Charles, Chem. Engr., Water Works & Sewerage Div., 3161 Joseph St., Montreal, Que. (Jan. '55) *P*

Bourquard, E. H., Chief of Flood Control, State Dept. of Forests & Waters, Education Bldg., Harrisburg, Pa. (Jan. '55) *MRPD*

Branham, R. B.; *see* Key Biscayne (Fla.) Water Co.

Brown, H. D., Supt., Water Works, Bloomington, Ind. (Jan. '55) *MP*

Buckeye Cotton Oil Co., The, Albert E. Logan, Assoc. Director of Eng., 2899 Jackson Ave., Memphis, Tenn. (Corp. M. Jan. '55) *RP*

Burnham, Thayer W., Biochemist, Dept. of Public Health, 112 N. Hamilton St., Madison, Wis. (Jan. '55) *P*

Cannon, Frank, Water Repair Dept., Abilene, Tex. (Jan. '55) *MP*

Cannon, H. R., Distr. Foreman, Water Dept., Abilene, Tex. (Jan. '55) *MP*

Cardwell, Robert M., Supt., North Waco Water Supply Dist., 2618 N. 20th St., Waco, Tex. (Jan. '55) *MRP*

Carlson, Carl E. C., Administrative Asst., Board of Water Com., Box 600, Denver, Colo. (Jan. '55) *MRPD*

Christy, Robert W., Engr., Link Belt Co., 2630 Holmes St., Kansas City 8, Mo. (Jan. '55) *P*

Church, Lloyd R., Village Supt., Clarendon Hills, Ill. (Jan. '55) *M*

Colony, William M., System Maint. Engr., Washington Suburban San. Com., 4017 Hamilton St., Hyattsville, Md. (Jan. '55) *M*

Cornett, Jack B., Cons. Engr., 2805 S. Pittsburg, Tulsa, Okla. (Jan. '55) *P*

Cox, Joseph B., Asst. Chief Engr., Elec. & Water Eng. Dept., 34 S. Laura St., Jacksonville 2, Fla. (Jan. '55)

Crabbe, Ben F., Mfer.'s Repr., Box 3413, Orlando, Fla. (Jan. '55)

Cunningham, Francis P., Engr., Neptune Meter Co., 4713 N. Knox Ave., Chicago 30, Ill. (Jan. '55)

Daley, James J., Project Engr., Purolator Products Inc., 970 New Brunswick Ave., Rahway, N.J. (Jan. '55) *F*

Dalias, B. B., Supt., Water Works, Caraway, Ark. (Jan. '55) *M*

Davis, Richard O., Prin. Civ. Engr., Burns & McDonnell Eng. Co., Box 7088, Kansas City, Mo. (Jan. '55) *RPD*

de Carteret, W., Sales Repr., Neptune Meters Ltd., 1430 Lakeshore Rd., Long Branch, Ont. (Jan. '55)

Dixon, Philip M., Field Engr., Peerless Pump Div., Food Machinery & Chemical Corp., 2850 N. Grand St., St. Louis, Mo. (Jan. '55)

Dodd, Donald N., Sr. Engr., Burns & McDonnell Eng. Co., Box 7088, Kansas City, Mo. (Jan. '55) *RPD*

Doka, George, Asst. Engr. Water Div., Rm. 111, City Hall, Sacramento, Calif. (Jan. '55)

Fellows, Frank, Supt., Operations & Maint., Gary-Hobart Water Corp., Gary, Ind. (Jan. '55) *MRPD*

Ferris, John G., Staff Engr., US Geological Survey, 407 Capitol Savings Bldg., Lansing, Mich. (Jan. '55)

Ferzacca, V. J.; *see* Pure Water Co.

Flanagan, Pat, Mfer.'s Agent, 3703 Granada St., Tampa, Fla. (Jan. '55)

Fleming, C. P., Supt., Water Dept., Middletown, Ind. (Jan. '55)

Frazee, John, Asst. Supt. of Utilities, Elec. & Water Dept., Auburn, Ind. (Jan. '55) *M*

Freese, Paul V., Asst. Supt., Sewage Treatment Plant, 5000 Overlook Ave., S.W., Washington 24, D.C. (Jan. '55)

Frizzell, Raymond, Gen. Foreman, Meter Div., Water Board, 418 Eleanor St., San Antonio, Tex. (Jan. '55) *M*

Gastonia Dept. of Public Health, W. N. Long, Jr., Sr. Public Health Engr., Box 710, Gastonia, N.C. (Munic. Sv. Sub. Jan. '55) *RP*

Gray, Russell T., Inc., Harvey A. Scribner, Pres., 155 N. Wacker Dr., Chicago 6, Ill. (Corp. M. Jan. '55)

Grewe, Leo F.; *see* Huntingburg (Ind.) Water Co.

Hagglund, R. B., Treas., Ralph D. Thomas & Assoc., Inc., 401 Metropolitan Bldg., Minneapolis, Minn. (Jan. '55) *PD*

Hahn, David B., Engr., Layne Texas Co., 9620 John West Rd., Dallas 18, Tex. (Jan. '55) *MR*

Hammerson, William Percy, Engr.-Draftsman, Dean S. Kingman, 153 University Ave., Palo Alto, Calif. (Jan. '55) *D*

Harcourt, P. W. E., Branch Mgr., Consolidated Engines & Machinery Co. Ltd., 241 Birmingham St., New Toronto, Ont. (Jan. '55)

Heil, Dick C., Regional San. Engr., State Dept. of Health, Bureau of San. Eng., 415 First National Bank Bldg., Greensburg, Pa. (Jan. '55) *P*

Henderson, Kenneth W., Engr., Malcolm Pirnie Engrs., 25 W. 43rd St., New York 36, N.Y. (Jan. '55) *P*

Hook, Melvin E., Asst. Mgr., Fox Chapel Authority, 401 Fox Chapel Rd., Pittsburgh 15, Pa. (Jan. '55) *MRPD*

Hopkins, David Walter, Chief Consultant, Valve Div., S. Morgan Smith Co., York, Pa. (Jan. '55) *PD*

Hsi, Eugene Y., Public Health Engr., State Dept. of Health, 2411 N. Charles St., Baltimore 18, Md. (Jan. '55) *MRPD*

Hull, Cecil H., Engr., Sheppard T. Powell, 330 N. Charles St., Baltimore 1, Md. (Jan. '55) *RP*

Hummel, Thurlow, Supt., Victorville County Water Dist., Box 577, Victorville, Calif. (Jan. '55) *MD*

Huntingburg Munic. Water Co., Leo F. Grewe, Supt., Huntingburg, Ind. (Corp. M. Jan. '55) *MRPD*

Hutchins, Roy D.; *see* Phillipsburg (Kan.)

Ivey, Gordon W., Supt. of Utilities, Homestead, Fla. (Jan. '55) *M*

Jack, David, Supervising Engr., Public Health Eng. Div., Dept. of National Health & Welfare, 207 Scientific Bldg., 425½ Portage Ave., Winnipeg 2, Man. (Jan. '55)

Jon, Gerhardt A., Borough Engr., North Arlington, N.J. (Jan. '55) *MD*

Jones, John N., San. Engr., Indiana Reformatory, Pendleton, Ind. (Jan. '55)

Kenworthy, Harvey W., Water Purveyor, Town Hall, Kearny, N.J. (Jan. '55) *MPD*

(Continued on page 100 P&R)

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(Continued from page 98 P&R)

Key Biscayne Water Co., R. B. Branham, Mgr., 30 Crandon Blvd., Key Biscayne, Fla. (Corp. M. Jan. '55) *M*

Kilburn, James S., Civ. Eng. Asst., Dept. of Water & Power, 316 W. 2nd St., Los Angeles, Calif. (Jan. '55) *D*

Kiahn, William H., Owner, Kernville Domestic Water Co., Box 113, Kernville, Calif. (Jan. '55)

Kraft Foods Co., Steven A. Bodnar, Mech. Engr., 500 N. Peshtigo Court, Chicago, Ill. (Corp. M. Jan. '55) *RPD*

Kuenzler, Emil J., Chief Inspector, Bureau of Water Register—Queens, New York Dept. of Water Supply, Gas & Elec., 32-11—205th St., Bayside 61, N.Y. (Jan. '55) *M*

Lee, Edwin W., San. Engr., US Army Corps of Engrs., 180 New Montgomery St., San Francisco, Calif. (Jan. '55) *RPD*

Lee, James H., Asst. Engr., Washington Suburban San. Com., 4017 Hamilton St., Hyattsville, Md. (Jan. '55) *M*

Logan, Albert E.; *see* Buckeye Cotton Oil Co.

Long, W. N., Jr.; *see* Gastonia (N.C.) Dept. of Public Health

Lutge, Theodore V., Engr., Water Works Div., Gannett Fleming Corddry & Carpenter, 600 N. 2nd St., Harrisburg, Pa. (Jan. '55) *PD*

Mahoney, John A., Supervisor, Water & Sewage Plant, Mendocino State Hospital, Box 212, Talmage, Calif. (Jan. '55)

Malone, Glenn D., Head, Equipment Div., Water Board, 106 Market St., San Antonio, Tex. (Jan. '55) *M*

Mascia, Vincent; *see* Wallingford (Conn.) Water Dept.

Mathieson, W. R., Secy.-Treas., The Assn. of Munic. Elec. Utilities of Ontario, 620 University Ave., Toronto 2, Ont. (Jan. '55)

Matthews, Seth H., Jr., Asst. Supervisor, Power & Utilities, Ethyl Corp., Houston Plant, Box 472, Pasadena, Tex. (Jan. '55) *MRPD*

McDaniel, A. B., Jr., City Engr., Calhoun, Ga. (Jan. '55) *MPD*

McDowell, Earl F., Supt., Water Dept., C.M.R. No. 31, Pekin, Ill. (Jan. '55) *M*

McInerney, Edward, Utilities Supt., US Air Force, Canadian PO Ernest Harmon Air Force Base, Stephenville, Newfoundland (Jan. '55)

McIntyre, Malcolm T., Water & Sewer Dept., Fort Lauderdale, Fla. (Jan. '55) *M*

McMasters, V. K., Supt., Production, Water Dept., Box 1266, Duncan, Okla. (Jan. '55)

Moffett, J. William, Jr., Tech. Asst. to Head of Sales Development Dept., Rohm & Haas Co., 222 W. Washington Square, Philadelphia, Pa. (Jan. '55) *P*

Moore, Harold, Draftsman, Water Dept., City Hall, Sacramento, Calif. (Jan. '55)

Morse, Roy W., Supt., Water Dept., 323 County-City Bldg., Seattle 4, Wash. (Jan. '55) *MR*

Mudgett, C. T., Director, Dept. of Public Utilities, Muskegon, Mich. (Jan. '55) *M*

Murphy, John A., Supt., Bureau of Admin., Bureau of Water, City-County Bldg., Pittsburgh 19, Pa. (Jan. '55) *MRPD*

Neel, Jack F., Asst. Engr., Washington Suburban San. Com., 4017 Hamilton St., Hyattsville, Md. (Jan. '55) *M*

Oelke, Clarence, Supt., Water Dept., Main St., Princeton, Wis. (Jan. '55) *M*

O'Gara, Daniel Joseph, Business Mgr., Bessemer Water Service, 1810—3rd Ave., Bessemer, Ala. (Jan. '55) *M*

Olson, John H., Jr. San. Engr., Akron Water Works, Kent, Ohio (Jan. '55) *MRP*

Palmer, Harold L., Sales Engr., Uhrich Supply, 1015 Gentry, North Kansas City, Mo. (Jan. '55)

Partrick, C. W., Supt., Dist. Water Works of Metropolitan Toronto, 51 Lawrence Ave. W., Weston, Ont. (Jan. '55)

Philip, R. H.; *see* Trafalgar Public Utilities Com. (Ont.)

Phillipsburg, City of, Roy D. Hutchins, City Engr., Phillipsburg, Kan. (Munic. Sv. Sub. Jan. '55)

Powell, Cecil C., Asst. Supt., Torrance Munic. Water Dist. No. 3, 1510 Cravens Ave., Torrance, Calif. (Jan. '55) *MD*

Pure Water Co., V. J. Ferzacca, Mgr., Logan, W.Va. (Corp. M. Jan. '55)

Ralisback, A. M., Sanitation & Sewage Disposal Plant Foreman, Bolters Air Force Base, Box 389, Mineral Wells, Tex. (Jan. '55) *MRP*

Richetta, Joseph D., Cons. Engr., P. J. Kleiser & Assocs., 671 Tippecanoe St., Terre Haute, Ind. (Jan. '55)

Risser, Joe, Supt., Water Works, Monticello, Ind. (Jan. '55)

Robinson, John Moore, Secy., La Mirada Water Co., 650 S. Spring St., Rm. 1030, Los Angeles, Calif. (Jan. '55) *MD*

Sanderson, Wallace W., Assoc. San. Chemist, Div. of Labs. & Research, State Dept. of Health, Albany, N.Y. (Jan. '55) *P*

Sapulpa Water Dept., Nolan W. Smith, Supt., City Hall, Box 60, Sapulpa, Okla. (Munic. Sv. Sub. Jan. '55) *MP*

Schatz, Edwin C., Asst. San. Engr., Bureau of Environmental Sanitation, State Dept. of Health, Albany, N.Y. (Jan. '55)

Schucker, George W.; *see* Baltimore (Md.) City Health Dept.

Scribner, Harvey A.; *see* Gray, Russell T.

Serrin, Joseph E., Civ. Engr., Office of Planning, Design & Eng., Dept. of San. Eng., 6216 Dunrobbin Dr., Washington 16, D.C. (Oct. '51)

Sherman, Donald B., Supt., Water Dept., Board of Public Affairs, Box 247, Chagrin Falls, Ohio (Jan. '55) *MD*

Simon, Stephen, Water & Sewer Dept., Board of Public Affairs, Aurora, Ohio (Jan. '55) *MRD*

Smith, Harold L., Cons. Engr., First National Bank Bldg., Stuttgart, Ark. (Jan. '55) *MRPD*

Smith, Nolan W.; *see* Sapulpa (Okla.) Water Dept.

Smith, Robert F., Field Engr., H. W. Alward, Inc., 161 Mt. Airy Rd., Bernardsville, N.J. (Jan. '55) *D*

Smith, Wilber A., Sr., Supt., Waynedale Water Co., Inc., Waynedale, Ind. (Jan. '55) *MP*

Sodemann, George L., Partner, Marr, Green & Opper, 3329 S. Michigan Ave., Chicago 16, Ill. (Jan. '55) *MP*

Stiles, Eugene T., Owner, Stiles Soft Water Service, 324 Main St., Madison, N.J. (Jan. '55) *RP*

Sweeney, James A., Supt., Water Works, 281 Lincoln St., Manchester, N.H. (Jan. '55) *MD*

Taylor, Harold O., Supt., Water Works Dept., 26 Wall St., Winchester, Ky. (Jan. '55) *MRPD*

Thurston, George B., Sales-Service, Dearborn Chem. Co., 4101 E. Naomi St., Indianapolis, Ind. (Jan. '55) *P*

Trafalgar Public Utilities Com., R. H. Philip, Mgr., Water Dept., Box 82, 8th Line, Oakville, Ont. (Corp. M. Jan. '55)

Troglia, Louis D., Contracting Engr., Chicago Bridge & Iron Co., 907 Lafayette Bldg., Detroit 26, Mich. (Jan. '55) *MP*

Trotter, Roy M., Cons. Engr., 3134 Eton Ave., Berkeley 5, Calif. (Jan. '55) *RPD*

Wade, M. L., Cons. Engr., Bank of Commerce Bldg., Kamloops, B.C. (Jan. '55)

Wallingford Water Dept., Vincent Mascia, Supt., 284 Washington St., Box 357, Wallingford, Conn. (Corp. M. Jan. '55) *MRPD*

Walter, C. Richard, Asst. Engr., Hazen & Sawyer, 110 E. 42nd St., New York 17, N.Y. (Jan. '55) *RPD*

Warrington, James B., Chief Operator, Water Plant, Box 2853 Univ. Stn., Gainesville, Fla. (Jan. '55) *P*

Wayne, Myron A., San. Engr., Michael Baker Jr., Inc., Rochester, Pa. (Jan. '55) *PD*

Weber, Frank P., Chairman, Water Dept., 40 Ridge Rd., North Arlington, N.J. (Jan. '55) *M*

Weichelt, Arthur, Consultant, Midwest Securities Co., 134 S. LaSalle St., Chicago 3, Ill. (Jan. '55) *MD*

Welch, Louis Lester, Jr., Sales Repr., Wholesale Supply Co., Inc., 828 S. State St., Jackson, Miss. (Jan. '55) *D*

Wilcox, Robert L., Research Asst., San. Eng., Massachusetts Inst. of Technology, 77 Massachusetts Ave., Rm. 1-075, Cambridge 39, Massachusetts (Jr. M. Jan. '55) *MRP*

Young, Charles Wayne, Engr., Butte Water Co., 124 W. Granite, Butte, Mont. (Jan. '55) *M*

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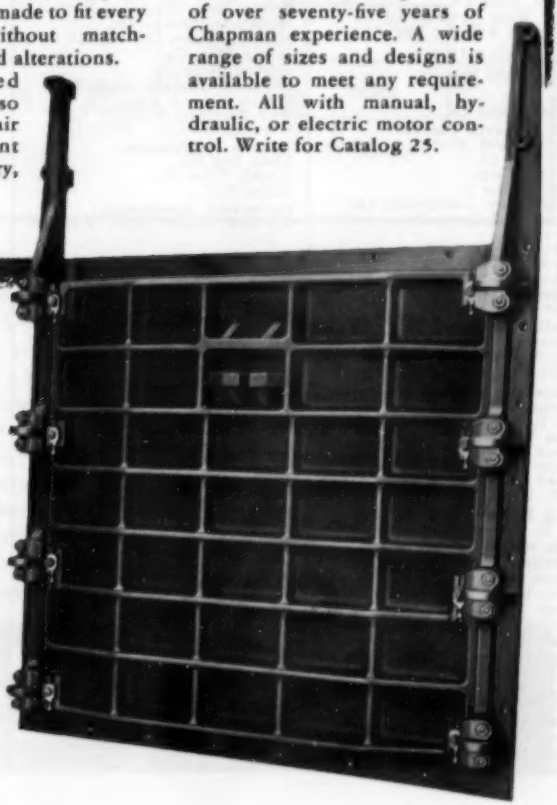

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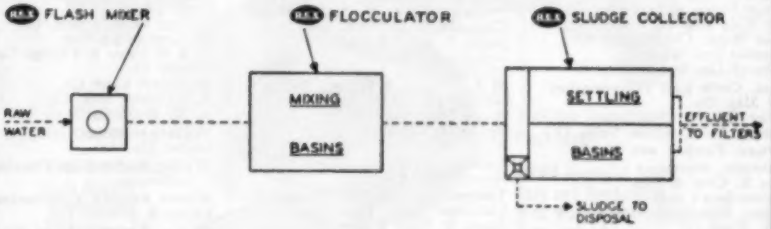

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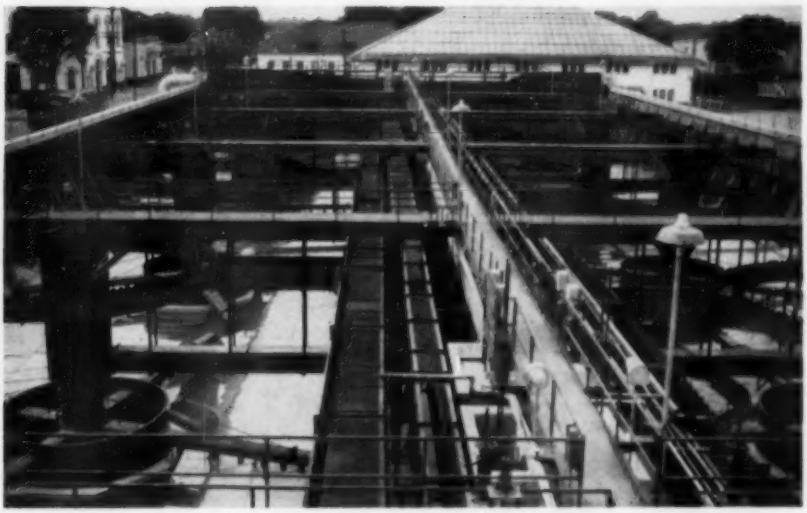
No two water treatment problems are exactly alike. The right solution to each can only be arrived at after a careful study of the local conditions. Variables such as raw water composition, rate of flow and results required automatically rule out the cure-all approach. The installation shown below is a good example of how equipment should be selected to fit the job . . . and not vice versa.



New Orleans, Louisiana | *Gets Immediate Softening and Clarification Capacity While Long Range Improvements are Made*

How to get immediate high-rate softening and clarification capacity for 100 MGD while long range improvements were made in another section of the plant . . . that was the problem faced by New Orleans.

A study of existing facilities showed that effective use could be made of two existing basins which had been used as grit chambers in the original plant. Twelve Dorrco Hydro-Treator* mechanisms, each 54′ 6″ diameter, were installed . . . six in each basin, with the basins operating in parallel at 50 MGD capacity each.

Other improvements now being completed in the plant include the addition of two Dorrco Monorake* units in one of the existing coagulation basins.

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Every day, nearly 8 billion gallons of water are treated with Dorr-Oliver equipment.

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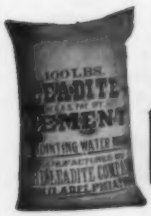

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